TECHNOLOGY TRANSFER IN HOUSING IN ALBERTA

Alberta
MUNICIPAL AFFAIRS

TECHNOLOGY TRANSFER IN
HOUSING IN ALBERTA

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EXECUTIVE SUMMARY

INTRODUCTION

In November 1987, the Housing Division of Alberta Municipal Affairs commissioned Thorkelsson Architects Ltd. to carry out a study of innovation and technology transfer in the residential construction industry in Alberta. The objectives of the study were:

1. to determine the process by which the housing industry makes decisions about adopting new products and/or methods,
2. to identify barriers to the adoption of new products or methods in Alberta's housing industry.
3. to identify factors conducive to the adoption of new products and methods in Alberta's housing industry.

APPROACH

The focus of the study was a number of innovations which are relevant to housing in Alberta. The innovations selected for analysis were:

1. Oriented Strand Board (O.S.B.).
2. Medium Density Fiberboard (M.D.F.).
3. Preserved Wood Foundations (P.W.F.).
4. Rigid Foam Insulation and Framing System (Nascor System).
5. Drywall Clips.
6. Air Tight Drywall Approach (A.D.A.).
7. Prefab Wood "I" Joists (Wood "I"'s).
8. 7-S Stressed Skin Panel System (7-S System).

These innovations were investigated through interviews of individuals connected with each of the innovations. The study also included interviews of selected builders to obtain information on their use of and attitude toward each of the innovations.

OBSERVATIONS

The study yielded the following observations. Readers should note that they derive from a relatively small number of interviews which limits their comprehensiveness and representativeness, as well as the degree to which they can be applied to the housing industry.

1. The process by which innovation and technology transfer takes place is not well understood, particularly by the innovators who are involved in it.

2. Innovators are not as skilled as they need to be in assessing and refining their innovation and explaining its full advantages to others whose support would help the innovation's acceptance.

3. There is a general lack of money to develop innovations.

4. The general ignorance of a house buyer about most aspects of residential construction precludes him from being an effective contributor to the trends in housing innovation as it applies to building technology, materials and products.

5. Builders by and large are not interested in incorporating innovations into their building processes and utilize a number of mechanisms to slow the adoption of innovation.

RECOMMENDATIONS

In response to these observations the study makes the following recommendations.

1. The innovation and technology transfer process should be researched and documented in detail in order to explain it to innovators.

2. Innovation start-up programs should be implemented to show innovators a way through the process and give them an idea of the resources they need.

3. A resource source guide should be prepared and made available to innovators.

4. Innovators should carry out their financing planning on the basis of two cash flows, one for continuing expenses and one for specific developmental costs of the innovation.

5. The amount of financial assistance to help develop innovations should be increased substantially from present limits.

6. The description of residential construction technology should be recast in systematic terms in order to give all parties to the process a clearer concept of what residential construction technology is.

7. A program should be introduced to upgrade the builder's knowledge of residential building technology so that he can better evaluate and utilize innovations.

8. The regulatory requirements and approvals process should be clarified to innovators, and regulators should be as cooperative as possible in identifying regulatory problems with an innovation.

9. A residential construction technical research centre should be set up to assist in builder education and the innovation process.

1.0 INTRODUCTION

1.1 STUDY BACKGROUND AND OBJECTIVES

Innovation is the natural consequence of an inquiring mind trying to solve a problem or to make something better than it was. The harnessing of innovation and transferring its effects and benefits into the marketplace is a major creator of economic activity and wealth, in addition to the expected general improvement of the social condition.

In the residential construction industry, however, the rate of innovation and the transfer of the resultant technology to the industry seems to occur at a low rate, particularly when compared to other sectors of the economy. Further, while a number of studies have been done which describe the innovation process in general and identify various impediments to it, the process by which innovations are developed and adopted by the residential construction industry is not clearly understood.

In response to this situation and to its interest in encouraging innovations in housing, Canada Mortgage and Housing Corporation (CMHC) commissioned the firm James F. Hickling Management Consultants Ltd. (J.F.H.) in September 1987 to carry out a study of technology transfer and innovation in the Canadian residential renovation industry. The general objectives of that study were:

- to examine the process of technology transfer in this indusry,
- to identify the factors which drive and/or constrain the process of technology transfer, and
- to identify the roles which government and industry can play in encouraging the diffusion and adoption of technology in the residential construction industry.

For similar reasons, the Housing Division of Alberta Municipal Affairs commissioned Thorkelsson Architects Ltd. in November 1987 to carry out a supplementary and complementary study in the same field. The objectives of this study were:

1. to determine the process by which the housing industry makes decisions about adopting new products and/or methods,

2. to identify barriers to the adoption of new products or methods in Alberta's housing industry.

3. to identify factors conducive to the adoption of new products and methods in Alberta's housing industry.

This report documents the results of the Alberta study.

1.2 STUDY SCOPE AND FOCUS

One of the intentions of the Alberta study was to strengthen the empirical basis of the C.M.H.C. study. To achieve this, the study focused on a more in-depth analysis of a limited number of actual or attempted innovations pertinent to Alberta.

The selected innovations were chosen in cooperation with officials of the Housing Division of Alberta Municipal Affairs. The main criteria for selection were:

1. their current applicability to the residential housing industry in Alberta,

2. the presence of the innovation in Alberta,

3. the actual or potential impact on the Alberta economy,

4. the complementarity of the cases to the C.M.H.C. study.

The following innovations were selected for analysis:

1. Oriented Standard Board (O.S.B.)

   This is a panel material made from aspen chips at two plant locations in Alberta by Pelican Mills. While it looks similar to waferboard, the manufacturing process orients the chips in alternate layers in orthogonal directions much like plywood, giving the product a strength comparable to plywood.

2. Medium Density Fiberboard (M.D.F.)

   This is a panel board material that is made of partially pulped wood fibers mixed with resin and compressed into a sheet with machining properties superior to particle board. It is produced by Blue Ridge Lumber in one plant in Alberta.

3. Preserved Wood Foundation (P.W.F.)

   This is a system of constructing a residential basement from pressure treated wood. It is not a proprietary product and can be constructed by any builder if he so wishes. The pressure treated wood is produced in a number of plants in Alberta.

4. Wood Framing System with Rigid Foam Insulation (Nascor System)

   This is a proprietary system using styrene foam and wood studs to construct a insulated structural wall system. It is produced by Cano Structures in one plant in Alberta.

5. Drywall Clips

These consist of a galvanized steel "U" with a leg at the bottom of the "U", which clips on the drywall panel before it is installed. When the panel is installed the clips are screwed to adjacent wood members instead of blocking behind the edges of the board, thus saving the supply and installation of much of the corner blocking in a house. The device is manufactured in a plant in the United States.

6. Air Tight Drywall Approach (A.D.A.)

A.D.A. has a number of elements which include the use of gypsum board and gasketting as an air barrier, and paint as a vapour diffusion retarder. This technique eliminates the need for a polyethylene sheet vapour barrier.

7. Prefabricated Wood "I" Joist (Wood "I")

This is a manufactured structural joist consisting of an oriented standard board web joined to finger jointed stress tested lumber flanges with a patented joint. They are made by Jager Industries in one plant in Alberta.

8. 7-S Stressed Skin Panel System (7-S System)

The system consists of oriented strand board facings and webs with an injected urethane foam core. The panels are used for walls, floors and roofs. It is produced by 7-S Structures in a pilot plant in Alberta.

1.3 APPROACH

The decision to analyze a number of cases suggested an interview approach.

Proponents of each innovation were identified as well as industry wide experts who likely had an insight into the history of the innovation's development. In addition a cross-section of builders - the prime users of the innovations - were approached to discuss all of the selected innovations.

The interview formats were developed and the information to be collected was identified by utilizing the investigative work into the innovation and technology transfer process done by J.F. Hickling Management Consultants of Ottawa. This investigative work, which reviewed and evaluated much of the literature on the innovation diffusion process within a conceptual model developed by the firm, was carried out as part of an overall study of the process being done by the firm for Canada Mortgage and Housing Corporation. In order to facilitate the co-ordination of results of the Alberta and C.M.H.C. studies, the interview format and the scope of topics covered in the interview guides was kept similar.

1.3.1 Interview Guide for Proponents of Innovation

The interview guide for the proponents of the innovation and any industry wide experts who were familiar with the innovation included the topics summarized below. The interview guide is shown in Appendix A.

1. Information about the respondent and how he was associated with the innovation (questions 10 - 23).

   The purpose of this topic area was to establish the connection between the innovation and the respondent, in order to help interpret the responses. These questions also afforded opportunities to obtain additional details about the respondent's personal experience in the innovation process.

2. Data on the innovation (questions 24 - 32).

   In this topic area the respondent classified and characterized the innovation using a number of objectively based categories including a general functional description, source of the innovation, geographic origin, significant dates in the development process, and the motivating factor. The purpose of the topic area was to provide an initial grouping of the innovations against which the remaining topic areas would be compared.

3. Technology transfer activities (questions 33 - 37).

   In this topic area the respondents were asked to discuss whether in the course of the innovation's development certain activities such as basic research, applied research, feasibility studies, marketing studies had been done and to what extent.

The remaining questions (questions 38 - 44) explored various factors which explained and/or affected the extent of technology transfer applicable to the selected innovations.

4. Participants in the introduction and acceptance of an innovation (question 38).

   The respondents were requested to consider the residential housing industry as consisting of fourteen major components. They were then asked to consider which industry components supported the innovation in question, which hinder the use of the innovation and which had little impact. By asking the respondent to consider the situation both at the innovation's introduction and at the present time, it was possible to note any shift in support for the innovation.

5. Benefits from the innovation (question 39).

To be successful, an innovation must reduce costs, such as material and labour costs (which may involve material substitutions) and/or improve the quality or performance of a product for the benefit of a home buyer. In this topic area the respondents were asked to consider the impact of the innovation in terms of 11 factors which research has determined to be key in determining the utility of an innovation to the residential construction industry. These factors include construction time, labour time and skills, material costs, first cost and life cycle costs, energy performance, safety, appearance, comfort and durability.

Parallel to considering the impact of the innovation on these factors, the respondent was also asked to discuss the prevailing market attitude with respect to each factor toward and in terms of the need for changes in the field the innovation is attempting to penetrate. By including this second part it was possible not only to get ideas about respondent perceptions of the benefits of the innovation to the contruction process and quality of the product but also about whether the market perceives a need for improvement in present practice.

6. Benefits which the innovation confers upon industry users (Question 40).

An innovation's utility is also determined in accordance to the benefits it confers upon the industry component that uses it. Research indicates that these benefits consist of the following: relative advantage over the competition, compatibility with present way of doing things, simplicity of use, convenient to try, easy to understand and communicate to others. In this topic area the respondent was asked to comment on the scope of the conferred benefits and which industry component obtained them.

7. Risk assessment (question 44).

Respondents were asked to assess the apparent risks involved in using the innovation and determine who carried it both at introduction of the innovation and the present. The following types of risks were probed based on research: financial, product, competitive, information, market, management, strategic, reputation and liability. (Some of these risks overlap to a certain extent.) The examination of how risk was considered was intended to indicate whether the perceptions of risk focused on measurable factors such as financial risk or on more subjective factors such as reputation risk.

1.3.2 Interview Guide for Builders

The interview format for builders was somewhat simpler than that used for the proponents of the innovations and included the topics summarized below. The interview guide is shown in Appendix B.

1. Information about the respondent (questions 1 - 11)

   The purpose of this topic was to note a number of characteristics such as job description, background in construction, education, construction training which might have a bearing on the builder's perception and acceptance of an innovation.

2. General impressions of each innovation (questions 12 - 14)

   In this topic area the respondent was asked whether he had used the innovation and when, why he used it, whether he would accept recommendations in its use from the two industry components he most closely associates with - his sub-trades and the house buyer - and his opinions on market acceptance. The purpose of this section was to obtain builder attitudes toward the innovation, and how it related to his trades, the house buyer and the housing industry in general.

3. Benefits and risks (questions 15 - 17)

The issues explored in these questions were identical to those explored in topic areas 5, 6, and 7 discussed in the previous section (1.3.1) except that they were discussed from the perspective of the builder.

1.3.3 Interviews

1. Interviews with proponents of innovation and industry wide experts.

Upon review and approval of the interview format, and the final selection of the innovations to be studied, a search was conducted to find proponents of each innovation who had sufficient background to fully discuss all topic areas. This was relatively difficult in that in some cases proponents with very good knowledge of the innovation refused to be interviewed and others who were reportedly knowledgeable about an innovation were not. In all, 12 proponents of the selected innovations and industry wide experts were interviewed about all but one innovation.

The results of the interviews on each innovation were documented in accordance with the following outline:

- Information source.

- Description and present status of the innovation.

- Transfer activities carried out to date on the innovation.

- Factors affecting technology transfer.
  - .1 Market perception of the field the innovation is entering.
  - .2 Industry components involved.
  - .3 Factors affecting the diffusion of the innovation.

- Possible measures that might help the diffusion of the innovation.

The case study results are contained in Appendix C. The results of all the case studies were analyzed and are presented in Section 2.1 of this report, entitled "Attitudes and Actions of Innovators in the Technology Transfer Process."

2. Interviews with builders

The interviews with builders were conducted in the same time period as the interviews with the proponents of the innovation. A listing of contractors was prepared for the major centers in the province and initially a random selection of 20 was made and arrangements for interviews made. The task turned out to be difficult because many builders listed were either out of business or not interested in being interviewed. Approximately 40 attempts at contacts were made but only 13 interviews were completed. The distribution of interviewed builders by community are as follows:

Calgary:	5
Edmonton:	6
Lethbridge:	2

The builder interview results were structured so that they could be used in a statistical way. This was possible because all the builders interviewed gave their opinions on all the innovations. The results indicate a general builder preference and opinion on each innovation and are presented in Appendix D of the report entitled "Builder Perception And Use Of Innovations In Residential Construction". Most builders also provided commentary on and explanations of their opinions which greatly expanded the general understanding of the builder's role in the innovation. This understanding has been documented in Section 2.2 of the report, "Builder Attitudes Toward Innovation and Technology Transfer".

3. Findings and Conclusions

Findings and conclusions from the interviews are documented in Section 3.0 of this report.

2.0 OBSERVATIONS

2.1 ATTITUDES AND ACTIONS OF INNOVATORS

An innovation, from its inception as an idea, to the point where it is widely diffused in the market place takes a path with many steps. It is carried along this path by its chief advocate, the innovator, who is largely responsible for completing the journey. Some carry through the process with reasonable success; others less so for a variety of reasons as indicated in the interviews and case study results. The interviews suggest a number of specific characteristics about innovators. However these cannot be generalized for the low rise residential construction industry as a whole for at least two reasons: (1) the number of interviewees was small, which means that the views may not be entirely representative and (2) the case studies deal almost exclusively with manufactured materials and products. For this sector of the industry, as it relates to Alberta, the following observations are useful.

2.1.1 The Innovations and the Innovators

The eight innovations chosen for study are primarily oriented to some aspect of the use of wood. Only two, Air Tight Drywall Approach (A.D.A.) and Drywall Clips, do not use wood directly although the use of Drywall Clips does reduce the amount of wood used in a house. The large majority of the innovations are material systems or products. Only one, A.D.A. can be considered more a technique than a material or product. As a group,they represent a significant sampling of innovations involving basic material or product systems.

All of the innovations are young and none is so advanced in the marketplace as to be considered standard building practice. Most of the development work for all the innovations is post 1970 and two are at a very early stage of development with little market acceptance as yet.

The geographical origin of only two of the innovations is Alberta - the Seven-S System and the Nascor System (although the Nascor System is based on similar systems and technology developed elsewhere). Interestingly these both represent comprehensive integrated building systems. Three of the innovations, Preserved Wood Foundations (P.W.F.), A.D.A., and Prefab Wood "I"'s were originally created elsewhere but a great deal of applied research was done in Alberta to improve the product. These innovations also involve a fairly sophisticated systems approach to building. The remaining three innovations, Oriented Standard Board (O.S.B.), Medium Density Fiberboard (M.D.F.), and Drywall Clips were created and developed elsewhere (outside Canada) and have been imported virtually unchanged into Alberta. These innovations are exclusively a material or a product.

The innovators who were interviewed, except for those involved with A.D.A., are associated with or have become part of manufacturing teams. The manufacturers range from very small firms to large scale manufacturing enterprises.

There appears to be a relationship between the geographical origin of the innovation and the size of the innovator. The innovations with an Alberta origin are being carried by small organizations with limited resources. Those innovations created elsewhere but significantly upgraded in Alberta are also being carried by relatively small organizations, although some of the manufacturing components such as the firms making pressure treated wood, are large. The innovations that have been imported into Alberta with little change, however, are being supported by the largest organizations of the group. Even pressure treated wood, although not part of this study, is an innovation that falls into this category.

There are a number of reasons why this is so starting with the fact that the imported innovations were capital intensive or were sufficiently proven in the marketplace with a high volume of production that only a large organization could tackle them. It would appear however that large Alberta based organizations are more interested in something proven even if it is not "home grown" than in local innovations. In addition, the subsequent applied research done by these organizations appears to be small in relation to the organizations' size when compared to the work being done by the smaller innovator entering the marketplace. What this suggests is that large organizations, even with all their resources, cannot be considered strong supporters of innovative development, and that the main innovative thrust will likely be from small resource-poor innovator organizations.

2.1.2 The Relationship of the Industry Components to One Another in the Innovation Process

For the purposes of this study, the low rise residential housing industry was divided into 14 components listed as follows:

1. House Buyer
2. Builder
3. Subtrades (10 major Subtrades listed)
4. Architects and Engineers
5. Building Material Supplier
6. Building Material/Product Manufacturer
7. Municipalities
8. Other Public Interest Organizations
9. Financial
10. Real Estate
11. Insurance
12. Energy Supplier
13. Trade Associations
14. Other

Of the eight innovations studied, six were originally developed by building material/product manufacturers, and two were developed by builders or subtrades. All but one of the innovations came into direct competition with existing products or systems which they sought to replace. Consequently they immediately came into some degree of conflict with the trade associations, manufacturers, suppliers, and trades people who depended on the existing product or system for their business. This conflict was reduced when the innovation co-opted one or more of the industry components that utilized the component. For example, an innovative wood product competing with an existing wood product does not seriously disturb the wood trade associations although there is some inevitable infighting. It appears that the less the innovation permits co-opting, the more difficult the acceptance of the innovation is likely to be, because there will probably be active (in contrast to passive) resistance to its adoption.

In the general introduction and diffusion of the innovation a number of the innovators noted that, in addition to the opposition of the competing industry, they had difficulty with builders in general, regulatory authorities, and to a lesser extent the real estate industry. Once the innovation was accepted, there was a clear shift to support the innovation among all three. The other components of the industry appears to have little impact in helping or hindering the introduction of the innovation, except the design industry, which either embraces an innovation or ignores it. Building materials suppliers generally tended to support the innovations studied because all of them probably meant improved sales.

The reason why in this study some industry components have little or no impact on the introduction or diffusion of an innovation appears to be that most of the innovations studied are oriented toward building technology, not consumer preference. Thus the home buyer is only peripherally interested and the financial and insurance industries tend to follow the lead of the regulatory agencies when it comes to material and products. The innovations chosen also generally had little impact on the mandate of the energy supplier and the trade associations.

The builder, however, is directly affected by the adoption of the innovations studied as are some of the subtrades. Their general reluctance to change appears to explain their tendency to resist the use of the innovation. (This is discussed in more detail in Section 2.2, "Builder Attitudes Toward Innovation"). The regulatory authorities, mindful of their responsibilities and the acceptability their approval gives the innovation, tend to require evaluations that are expensive and difficult to implement, which slows the technology diffusion process. Some realtors cause difficulties for innovators because they tend to follow the lead of the builder with whom they generally have a close association.

2.1.3 Technology Transfer Activities

There was great variety in types, quality and intensity of activities undertaken by innovators in bringing their innovation along. In almost every activity area, one innovator had done considerable work where another had done none. Where there was some commonality regarding an activity, the levels of performance ranged widely. There was, however, a number of common threads which can be identified. The following describes some of the general characteristics of the activities carried out by the innovators.

1. In the area of basic research little work was being done although some innovations would be helped by such research. This is probably because basic research entails specialized skills which are costly to obtain if the innovator does not already have them. It appears that only where the innovator was primarily a researcher by vocation or the innovating organization was large enough to have staff that recognized the need for research and could afford it was basic research being done. Unfortunately among the firms studied, those most able to afford such research have chosen to adopt fully developed innovations.

2. Upon reviewing the respondents' description of applied research activities, the amount and quality of applied research, product enhancement and development seems to be controlled by the skill level of the innovator, the innovator's desire to control the development of his idea and the amount of available funds. These factors appear to interrelate in the following way. First the innovator's initial idea stems from but is limited by his understanding of the problem which his innovation is trying to solve. Possibly the innovation has much more potential than the innovator perceives but this would only be discovered if he let others explore his idea. Most innovators are very reluctant at the early stages of idea development to surrender any control over their idea particularly to someone who would suggest he tackle it differently.

   The same concern for control is also often evident when the innovator is trying to apply his research results. He is likely to be very reluctant to allow development work be done that he does not clearly understand and will want the applied research to follow methods he is familiar with. Thus, for example, where a more theoretical approach to analysis of an innovation might be beneficial but require the use of outsiders, the innovator might opt for the physical modeling approach because he is much more familiar with hands on modeling.

   The innovator often thinks he is expected to work this way. At the start of the process, the innovator is usually the only believer in his idea, and must depend completely on his own resources to develop it. If he has little money, which is likely the case, he has only his time and skills to expend on the innovation. This for many innovators has its bright side because many believe that if outside funds were available to pay for outside skills it would probably mean a loss of control.

3. It seems that generally only the large innovator organizations carried out feasibility studies and market studies. It is hard to determine whether this is standard practice, however, because the large organizations were assessing already existing technologies in order to determine whether they should be brought into Alberta or not. This kind of study is much more clear cut and easier to carry out than on a relatively unknown and unexploited innovation. According to the interviews most of the innovators seem to be confused about the nature of such studies, why they are needed and when they are done.

4. The lack of involvement in government was generally a disappointment to most of the innovators, with most indicating that they had received what they considered to be relatively little help. Grants were very small in relation to overall capital requirements, and most were not clear as to how if any nonfinancial government assistance was provided. The general expectancy seemed to be not to count on government for much and to get at what was available usually costs the innovator more than the assistance is worth. Interestingly many thought that regulatory evaluation and approval, although a hassle, was a positive virtue because it gives the innovation a stamp of approval, which is always valuable in the marketplace.

5. In the area of marketing, including ongoing market analysis and field market testing, there was a variation in the levels of activity but the general trend was to do little. Few of the innovators approached marketing in a comprehensive way although a couple had specific marketing initiatives. While the larger innovator organizations studied do have resources dedicated to marketing, most of these are selling into proven markets, and have a more steady state approach to the need to market. By contrast, newly introduced innovations need vigorous, enlightened marketing, a skill probably in short supply in both small and large innovator organizations.

6. With respect to financial and business planning, all of the innovators are aware of the necessity to plan although there is not a concensus of exactly what this entails. Business planning, as it relates to the innovation, does not seem to be an exercise innovators are carrying out, although this is not the case with the largest innovative firms which tend have comprehensive business plans.

2.1.4 Level of Technology in Residential Construction

In the full spectrum of technology, residential construction is considered either "low" or "medium" technology. Seldom is it "high" technology. Those that are likely to be innovators are those that probably have had some continuing involvement in the industry, and consequently perceive of their ideas within the context of not only the residential technology of the day but generally with in the framework of the present skills and management of the residential construction process. This skill and management level is not high and the industry appears unable to attract many who could improve it.

While some of the innovations may be very imaginative, efforts to apply them are limited by the skill level of the innovator. This was apparent in some of the case studies where the inherent potential of the idea was not being fully exploited by the innovators. Much of the work was limited by the range of skills inherent to the innovator teams. In the innovations where this was not evident, the innovating organization tended to be either relatively large with a wide range of resources at hand or was exploiting development work done elsewhere. From this it would appear that many innovations do not get past the idea stage simply because many of the likely innovators in the industry do not have the skills to measure and effectively define the properties of their innovation, and relate them to potential users.

2.1.5 The Impact of Marketing and Information on Innovation and Technology Transfer

An innovation competing with an established practice or technology is at a disadvantage since much effort has to be expended to formulate and distribute information on the innovation, while little or no equivalent effort is required for the competing existing technology. Disseminating information about an innovation should be a large part of the initial market strategy, but the interviews indicated that marketing was not a well understood activity. Their comments often suggested that many innovators consider the merits of their innovation self evident, and therefore they do not see the need for extensive marketing. Few of the innovation proponents interviewed knew of or expected to see a comprehensive advertising campaign on any of the innovations studied.

2.1.6 Motivations to Innovate

The interviews suggested three general motivating environments which foster innovative ideas. The first was a general dissatisfaction with the status quo. This was the position of the residential construction industry at the time of the energy crisis when the energy efficiency of typical residential construction techniques were questioned. In situations where there is dissatisfaction with the status quo, the general objectives of innovative effort are reasonably well known as are the criteria for assessing the merits of the innovation. Under these circumstances, the justification for innovation is easy to understand and many see a window of opportunity to make money.

The second motivating environment for innovation is changing regulatory requirements, generally as a result of changes in policy. For example, as a result of the energy crisis, policy initiatives resulted in regulatory changes redefining the amount of insulation required in the walls of a house. A redefinition of regulatory requirements acts much the same way as does general dissatisfaction of the status quo but with increased clarity of effect. Once the decision to change the regulation is made, the objectives and criteria for evaluating innovations are very clear and development and diffusion is fast.

The third motivational environment is one where the innovator responding to his mileau produces an idea that is somewhat novel but which he thinks will be accepted and used once it is understood and made available. These innovations do not always fulfill a clear or readily accepted objective. Such innovations are the most difficult to evaluate.

Of the innovations studied, five appear to be primarily the product of the third motivational environment where an "opportunistic" innovation has been created. These innovations are Preserved Wood Foundations (P.W.F.), Rigid Foam Insulation and Framing System (Nascor), Prefabricated Wood "I" Structural Beams, Drywall Clips and the Prefabricated Stressed Skin Foam Core Panel (Seven-S). These innovations as a group appear to be having the greatest difficulty in getting accepted into the market. This is partially due to the difficulty the user has in assessing clearly the advantages and disadvantages of the innovation.

One of the innovations, Air Tight Drywall Approach (A.D.A.), appears to be the result of general dissatisfaction with the status quo. There is no significant propietry component to A.D.A. so there is not great monetary benefit to anyone except the user of the technique. While the diffusion of this innovation at its infancy, it will likely be accepted because its purpose and benefits are easily assessed.

The remaining innovations studied, Oriented Stand Board (O.S.B.) and Medium Density Fiberboard (M.D.F.), appear to be motivated by both dissatisfaction of the status quo and an inspiration on how to use wood ina novel way. Trying to use wood in a novel way was probably the primarily motivator because the innovating firms were already in the business of making wood products. Market dissatisfaction with present products in the marketplace was a smaller factor because suitable products already existed in the marketplace, but were becoming increasingly expensive.

None of the innovations was the result of revisions to regulations. Rather the converse was true, which is to say that all innovations were affected to some degree by the existing regulations. While some had no difficulty in conforming, others, such as O.S.B., P.W.F. The Nascor System, Prefab Wood "I"'s, A.D.A. and the 7-S System have had, and some continue to have difficulty in satisfying present regulations.

2.2 BUILDER ATTITUDES TOWARD INNOVATION AND TECHNOLOGY TRANSFER

The widespread diffusion of an innovation in residential construction ultimately is controlled by the rate at which builders decide to use that innovation. In the decision to use the innovation, the builder is influenced by the degree to which the other components of the residential building industry act as advocates or critics of the innovation. Builders' acceptance and use of an innovation is also affected by other factors including his construction education and his approach to marketing his product. These factors which became apparent during the interview process are discussed below.

2.2.1 Builder Education and its Affect on Technology Transfer

The interviews indicate that builder education is by and large limited to experience in the field. This field experience is learning how to build with little understanding of the theory of building technology. While the builder has a safe familiarity with his field experience, he has very few skills and little knowledge of how to evaluate a new idea except through the route of field experience. This makes it difficult for a builder to change his practices without an extremely strong incentive. Most builders profess not to be really interested in reading and do not spend much time going over the literature on various ideas that do come their way, because they do not have the background to assess it properly and they think it is likely biased. In addition, they do not expect much in the way of useful ideas from their trade association, because the competitive nature of builders in the marketplace will not allow them to co-operate except in matters either clearly benefiting all members (like successfully lobbying for regulatory changes) or clearly not of any significance (like golf tournaments).

It appears that evaluation by field experience is the primary mechanism by which innovations are accepted in the residential construction market place. Builders watch what other builders are doing, in many cases by prowling around their building sites, usually without contacting each other personally. Few are adventuresome enough to actually try a new idea mainly because they have no background skill in evaluating its properties except through field experience. They therefore watch what they consider to be industry leaders and, if these leaders start using an innovation, they are also likely to seriously consider its use. On the other hand if such leaders have a bad experience with the innovation, this will result in a major setback in the innovation's diffusion.

2.2.2 The Position of Building Industry Leaders in the Technology Transfer Process

Most builders consider the leaders in their industry to be those that are successful, and the general measure of success is the number of houses sold, not how innovative the firm is. Such leaders have arrived at their position of success by marketing and only incidentally by the use of any innovations. In fact, as the firm becomes more successful, it generally becomes dominated by marketers, not builders.

Housing marketers are not really interested in innovation unless it is part of their marketing strategy. The building side of the firm, however, would prefer that the marketers not sell innovation since it puts stress on them to change. The marketers for their part are confident that they are able to influence the decision to buy in a way that goes beyond the features and quality of the house. They therefore believe they can control the need to respond to change. Eventually, however, they get overtaken by other firms and either renew themselves or go out of business. At the height of their success, other firms look to them for trends and direction. In most cases, the successful firm markets the status quo, providing the rest of the industry little example or incentive to change.

While the above senario is not true in all cases of builder growth and success, some builders indicated that during earlier employment experience with "successful builders" the builder was reluctant to introduce new concepts but, when it did occasionally make a change, many other builders followed. Other smaller builders interviewed indicated that their attitude toward the use of a new idea is improved if they see other "significant" firms using it.

2.2.3 Innovation as a Marketing Concept

For many builders, being innovative is not a way of life or a matter of practice, but a marketing concept. Most of those who considered innovation important expressed it in terms of the market advantage they thought it might give rather than something to be incorporated in their building. No builder interviewed made it a standard practice to be on the look out for new innovations in construction although they thought they were sensitive to anything that reduces costs substantially.

In fact, the majority of builders thought it a market advantage to be traditionalists not innovators. They liked the idea of marketing a house which they claim is built to the old and, by implication, better standards and generally believe that this is what the house buyer wants.

2.2.4 Inducements and the Technology Transfer Process

Builders, while they may not be able to understand the non-financial benefits of using an innovation until they have gone through the risky exercise of actually trying it, clearly understand the benefits of reduced costs. In the housing industry, it appears that the sense of risk involved in discovering significant non-financial benefits to an innovation is so high the cost saving must be large and easily recognized to convince the builder to try it. There are innovations where most, if not all the benefits of use are non-financial. To get over the high threshold of builder resistance, some innovators resort to short term financial inducements to get the builder to use the product so that he can see its benefits. For one of the innovations studied it appears that this was the major method used in getting the builders initally to use the innovation.

While the use of incentives is a widespread practice in industry as a whole, in a sense it provides a short term reward to those who actively resist using the innovation. It reinforces the builders natural inclination not to change. It also promotes a counterproductive response in the builder when confronted with a home buyer requesting a change. In almost all cases the builder sees a request for change as an opportunity for financial benefit and will charge an extra whether one is justified or not. Thus the innovators and builders have unwittingly set up a system of financial barriers to the acceptance of innovations.

2.2.5 The Management of the Building Process and the Ability to Recognize the Benefits of Using Innovations

Most builders are almost completely self taught when it comes to managing the process and business of building. This applies particularly to the relationship between construction methods and costs. Most builders want only enough construction costing guidelines to ensure a reasonable level of profit. The fact that they are not sufficiently interested in learning more about the relationship ensures that most never know of an inadequancy until they go out of business.

The rudimentary way many builders approach the construction process-cost relationship limits their ability to measure the benefits of an innovation unless such benefits are extremely large or obvious. Thus many potential innovations are not used simply because the builder does not have a sensitive enough system to identify the benefits. If the builder cannot see any benefits, he is reluctant to change. In all the innovations examined in the interviews, those which were known to produce primarily non-monetary benefits were having the least amount of acceptance by the builders.

2.2.6 The Energy Crisis as a Force for Change and Its Impact on the Acceptance of Innovation

The last 15 years have seen a great deal of turmoil stirred up in residential housing industry by the energy crisis. The impact of the crisis was to focus attention on existing residential building technology and how to change it to be more energy efficient. Thus began what was for the residential building industry a very intense period of housing technology innovation, the thrust of which was energy conservation. This meant that many innovations were being introduced which among other things reduced the energy consumption of the house. Since then the energy crisis has subsided and, along with it, the need by many to seriously consider residential energy conservation. This has eliminated part of the rationale for many of the innovations introduced during this period and has allowed a sector of the residential construction industry to continue with less energy efficient construction practices. At present, there are differing view points in the marketplace, each with a supporting rationale, making it difficult for the average house buyer and builder to determine the full value of many of the more recent innovations. This is certain to create a level of frustration with innovations and their advocates. It also suggests that there has to be a continuity of purpose, to maintain an environment conducive to innovation.

2.2.7 The Relationship Between Builders and House Buyers and its Impact on the Acceptance of Innovation

In considering adoption of an innovation, most builders think it important to consider house buyer preference and wishes. While they might be receptive to an innovation, they believed they have to take into account buyers' conservatism and cost consciousness. Builders believe buyers do not want the builder experimenting on them. This suggests that, to an extent, builders are using house buyers as an excuse to not accept innovations.

The practice appears to occur in the following way. First house buyers generally recognize that they are generally uninformed about house construction and that they have to trust the builder in many respects. Some builders, taking advantage of this ignorance, try to obtain concessions or propose additional costs for items that either do not involve expenditure or reduce the builders' costs without directly benefiting the house buyer. This would include house buyer requests for changes. The basis for this attitude towards changes from the builder's point of view is to increase profits or to avoid delays which cost them money.

The house buyer's only real response because of his unfamilarity with residential construction technology is to either accept the extra cost or withdraw his request. Since withdrawal is probably more prevalent than acceptance, the builder imputes to the house buyer a money conscious conservative nature which chooses against innovation. Actually, it appears it is the builder who does not want innovation unless he is well paid to accept it.

3.0 FINDINGS AND CONCLUSIONS

This section documents the results of the analysis carried out in this study. The results have been organized to correspond with the study objectives. Readers should note that conclusions are derived from a limited number of case studies and interviews. This affects the comprehensiveness of the findings and limits the confidence with which the conclusions can be generalized.

3.1 THE HOUSING INNOVATION PROCESS

Analysis of how eight selected innovations have fared through the innovation process and how they are received by the prime user, the builder, gives an impression of the innovation process as it relates primarily to materials and products for residential construction in Alberta.

To begin with there appears to be a positive motivating environment in Alberta for innovation. There is firstly an entrepeneurial spirit that has always been acknowledged. Combined with the recent economic downturn and the provincial government's general policy initiatives concerning diversification of the economy, this spirit has fostered innovations in many sectors of the economy, including the residential construction industry. The strength of this spirit is indicated by the fact that the majority of the innovations studied were of the "opportunistic" type, and not the result of specific industry problems or regulations.

Secondly, the innovations are generally ambitious in scope, particularly those originating in Alberta. Even the largest organizations studied, although they were importing proven innovations into the province, selected leading edge technologies and were, in comparision to established manufacturers in the same field, relative newcomers. The ambitious nature of the innovations is best indicated by those smaller firms who are attempting to introduce relatively sophisticated ideas such as systems building and component manufacturing and assembly into what is essentially still a craft industry.

While acknowledging the positive inclination to innovate, the fact that relatively few innovations have been successfully introduced in residential construction raises questions about the reasons for the apparent contradiction. The following reasons are offered.

The first is that the positive encouragement to innovate is relatively recent in Alberta. Given the length of time it takes to fully develop and successfully market an innovation, there has not been enough time for many to be realized yet. It is possible with sustained encouragement that there will be an increased flow of innovative ideas attempting market penetration in the future.

A second reason for few innovations is the limited scope of the provincial economy. The province's economy has been essentially resource based and oriented toward the volume production of raw materials. In the effort to diversify and encourage innovation, the first emphasis is likely to be in the development of new materials and products, building upon an understanding of the process derived from watching existing industry.

This limitation in scope is apparent in the selection of the innovations studied. Research indicates that while innovations in residential construction can be grouped into seven subject areas, this study focuses upon only two, building materials and building products, with only one innovation falling completely in a third subject area - construction techniques. There were no studied innovations in the subject areas of construction equipment, building equipment, associated construction services, and construction business management. While the selection of innovations to be studied was intentional it was also partially determined by the fact that there are in Alberta few easily identified recent innovations in the subject areas other than those selected.

A third reason for the slow rate of successful innovations is that the innovators' skills and resources do not match the scope of their innovation and its development requirements. This is indicated in the approach to applied research taken by the majority of the innovators, which appears to be more "low tech" than their innovation warrants.

The industry components that could provide them with the most easily available developmental skills are the architects and engineers, but it appears that, as a group, architects and engineers play a minor role in all aspects of residential construction technology. In the one innovation where the mandatory use of engineering skills was determined by regulation, the rate of development and market acceptance of the innovation has improved.

The fourth reason for slow development of innovation in residential construction in Alberta is that while the innovators are anxious to succeed they have a limited knowledge of what is involved. In particular the studies showed that feasibility analysis, market studies and planning are not well understood tasks, nor are they acknowledged by some innovators to even be required. This lack of understanding firstly results in much more work for the innovator in backtracking and re-doing. It also takes much more time, possibly to the point that the innovator quits.

The fifth reason affecting the slow rate of innovation and technology transfer in residential construction is that the prime recipient of the new technology - the builder - does not want it. Builders in Alberta by and large have not felt the thrust of the innovative spirit and tend to support the traditional methods of residential construction. While there are a variety of reasons for this it is partially compounded by innovators' general lack of marketing plans to encourage the builders to use their innovations.

A final reason for the slow rate of innovation is possibly the level of assistance available to innovators from government. Other than encouraging the principle of innovation in its diversification policy, government assistance is not comprehensive, although what is provided may well exceed what is done elsewhere. At present there are a number of grants available for research and development which, however, are generally small compared to the costs of developing even a small innovation. Further the poor industry response to innovation apparently is not being considered.

3.2 FACTORS AFFECTING TECHNOLOGY TRANSFER IN HOUSING

Each of the innovations studied had its own unique reasons for being, and each had unique problems in its development and market acceptance. While the prime motivation for an innovator to push an innovation is the opportunity to profit, the innovation must show clear cost/benefit advantages to the end user to be successful in the long term.

The simpler these cost/benefit advantages are to understand, the easier the innovation will be to accept. However, the study indicates that the relationship among the intrinsic qualities of an innovation in respect of its benefits and costs to the user is generally not clear at all. Furthermore the acceptance or non-acceptance of an innovation in the marketplace appears to be somewhat arbitrary, and seems to have much more to do with the process of adoption than the quality of the innovation. This is because there are impediments in the process which influence the course of an innovation's development and adoption. These impediments appear to be as follows:

1. Lack of Knowledge of the Process Involved in the Development and Adoption of an Innovation

   The innovation process is not simple or easy. It consists of many steps and takes considerable time under the best of circumstances. It is not a well studied process and most innovators appear not to have a good overview of what is involved, particularly in assessing feasibility and market acceptability.

2. Lack of Skills in the Innovator Team to Fully Assess, Refine, and Explain the Innovation's Advantage

   Innovative ideas come to people at all levels of training and skill. The exploitation of an innovative idea is often limited by the training and skill of the innovator as well as his proprietary concerns about letting others work on his idea. As well there is a lack of appreciation of the marketing function as an essential aid to getting the innovation accepted.

3. Lack of Money to Develop the Innovation

   Many of the innovations for the low rise residential construction industry are not as capital intensive as in other sectors of the economy. On the other hand, they are also not very glamorous and do not involve potentially large profits. Consequently they are not attractive to most private capital.

4. Resistance to Change on the Part of the Builder Who is Generally the Prime User of the Innovation

   Observations of the builders' reactions to the innovations showed that the builders tend to resist change. An innovation has to exceed a minimum threshold of clearly understood benefits before the builder will consider the innovation. The most clearly understood benefit is a significant cost saving.

5. Ignorance of the Issues By the End Consumer, the Home Buyer

As the end purchaser of the product produced by the residential construction industry, the house buyer has the potential to exert a major force on the industry in defining the direction of innovative efforts. To a certain extent, this already exists in cosmetic areas, but in most other areas the house buyer tends to defer to the builder because the buyer is not in the position to properly evaluate the benefit of the innovation. The reasons for this appears to be that home buyers do not know how or where to get useful, significant information on the products and systems that go into a house. Instead they rely on the industry to provide them with a good home.

3.3 MEASURES TO INCREASE OR FACILITATE THE TRANSFER AND ADOPTION OF INNOVATION TECHNIQUES AND PRODUCTS IN ALBERTA

This section outlines a number of recommendations to facilitate the development and introduction of innovations to the residential construction industry. These recommendations are essentially conceptual ideas that stem from the analysis carried out in this study. They are stated without reference to existing efforts.

1. Innovation Process Research

The innovation process should be researched sufficiently to develop an easily understood explanation of the process to all interested parties. This could be laid out in the form of a guide with check lists so that potential innovators, particularly small ones, have an idea of what is involved in taking an innovation to market.

2. Innovation Start-Up Program

Innovators at a very early stage should obtain a preliminary evaluation of their innovation, which would assist in defining the innovation's cost-benefit relationships to the primary user and the likely development requirements and marketing possibilities for the innovation. These would all be incorporated into an innovation development plan. In order to assist in the preparation of the innovation development plan it should be possible to set out general guidelines for the conduct of such an evaluation so that it can be completed by either the innovator or a consultant team. Such a start up program would help the innovator set out his development plan and inform him of the scale of resources that will have to be committed to the project. It would also assist government in determining its level of support. The suggestion is to set out an innovation start-up program for the residential construction industry which would include guidelines for evaluating the innovation. As part of the program the government should consider supplying grants to pay for the evaluation.

3. Resource Sources for Innovators

Innovators are often not aware of what types or amounts of resources are available to them. The innovation process as it is presently conducted appears to include the haphazard discovery of resources usually in the wrong sequences to provide the most value to the innovator. It would be a great benefit to make available a directory of program and financial resources applicable to the innovations in the housing industry.

4. Financial Planning Strategy

The investigation of the innovation process and an innovation start-up program will likely show that the development of an innovation includes two distinct flows of money. The first is the flow required to maintain the day to day viability of the operations of the people involved in the innovation. The second is the flow directly related to the phased development of the innovation. Innovators should be encouraged to define their financial planning on this basis so that they have a better idea of their financing requirements and where to get the funds. For example, ongoing operations funding would be best provided by the private sector. Phased development of the innovation could be assisted with government grants. In the innovation start-up program the phased development of the innovation would be outlined and the government could outline its proposed participation if any.

5. The Size of Grants For Innovation in Residential Construction

The upper limits of presently available grants related to housing innovation is understood to be approximately $5,000.00 to $25,000.00, depending on the granting organization*. This is much too low, considering the general cost of development of an innovation and the detailed co-ordination and reporting requirements of present grant programs. Innovations in the residential construction industry, although low by general standards, can easily cost more than $500,000.00, not including organizational, manufacturing and marketing costs. The size of any grants could be determined on the basis of the results of the initial evaluation of the innovation and the phase development plan.

*It is acknowledged that the Province has provided large amounts of assistance for various developments. However, these amounts are usually directed toward and based on economic development objectives, not innovations.

6. The Low Rise Residential Building System

The ability to evaluate the utility of an innovation would be improved if the underlying construction technology was described in a systematic way. A description of the management of the overall building process could also be described in a systematic way. Such descriptions could provide an understanding of the intents and purposes of the building process, building technologies and assembly procedures. Such system descriptions could help make it easier for builders to understand how residential construction technology works and how to more effectively evaluate and incorporate an innovation into their building practices. A research study should be considered to determine and describe all the subsystems that make up the typical house.

7. The "Master Builder" Program

The study indicates that one of the main barriers to the adoption of innovation is the average builder's reluctance to change. This is due in part to the builder's fear of change because he does not have the skills to map out and follow an untried course of action. A program should be instituted to teach contractors how to deal with new ideas and incorporate new construction and business practices. The program should particularly stress the "why" of building in contrast to "what" or "how" to build. The program should be ongoing, voluntary and provided at no cost to the builder. Upon successful completion of the program the builder would receive the right to advertise himself as a "Master Builder" and keep that right as long as he periodically undertook refresher courses. The government could develop, finance and heavily advertise the value of the "Master Builder" to the home buyer.

8. Regulatory Approvals

The regulatory approval process is difficult for many innovators. This is partially due to the fact that descriptions and purposes of regulations are obscure, as are the evaluation and approval processes. Since the regulatory process is under government control, the government should first ensure the highest level of co-operation with the innovator. In addition, based on the result of the innovation start-up program and an acceptable initial evaluation of the innovation, the government should consider providing financial assistance to cover the expense of obtaining approvals.

9. Residential Construction Technical Research Centre

A technical research centre for residential construction should be set up to oversee and manage research projects and innovation development plans involving government funding. The research center would not do any of its own research but would act as a clearing house for contracted work. Included with the center would be libraries and information about all aspects of residential construction. The center could also operate the "Master Builder" program and develop information programs for house buyers. The center could be located in a well respected institution, so that it appears completely impartial to all components of the industry.

APPENDIX A

INTERVIEW GUIDE FOR INNOVATION SPOKESMEN AND INDUSTRY-WIDE EXPERTS

THORKELSSON ARCHITECTS LTD./MAYELL ARCHITECTS LTD.

PROJECT: TECHNOLOGY TRANSFER IN RESIDENTIAL CONSTRUCTION INDUSTRY

PROJECT NO.: 741

INNOVATION TO BE CONSIDERED: ______________________________

INTERVIEW SET-UP AND PRELIMINARY INFORMATION: Innovation Spokesman and Industry Wide Experts

1. Name of Person to be Interviewed: ______________________________
2. Initial Reason for person being selected: ______________________________

____

3. Present Place of Work: ______________________________
4. Title: ______________________________
5. Short Job Description: ______________________________
6. Address: ______________________ 7. Phone: ______________________
8. Initial Contact Method and Date: ______________________________
9. Interview Date: ______________________________

RESPONDENT'S ASSOCIATION AND/OR INVOLVEMENT WITH INNOVATION BEING CONSIDERED

10. When did you first know of or become interested in the innovation under consideration?

____

11. Did you do any actual work in the field/fields directly affecting the innovation in question?

____

____

12. Type of work ______________ ____ From: ______________ To: ______________

13. If not directly involved in the case under study what was nature of your interest?

____

14. At what stage of development was the innovation at the time of your first interest?

____

____

____

.1 ☐ Research/Feasibility Study Stage

.2 ☐ Prototype Evaluation Stage

.3 ☐ Regulatory Evaluation Stage

.4 ☐ Pre-production/Production Stage

.5 ☐ Marketing Stage/In Actual Use

15. Your personal point of view with respect to the innovation under study.

- .1 ☐ House Buyer
- .2 ☐ Builder/General Contractor/Developer
- .3 ☐ Subtrades (10)
    - .1 ☐ Concrete
    - .2 ☐ Framing
    - .3 ☐ Finish Carpentry
    - .4 ☐ Roofing
    - .5 ☐ Siding
    - .6 ☐ Plumbing
    - .7 ☐ Electrical
    - .8 ☐ Heating
    - .9 ☐ Flooring
    - .10 ☐ Drywall
- .4 ☐ Architect/Engineers
- .5 ☐ Building Material Supplier
- .6 ☐ Building Materials/Product Manufacturer
- .7 ☐ Municipalities
- .8 ☐ Other Public Interest Organizations
- .9 ☐ Financial
- .10 ☐ Real Estate
- .11 ☐ Insurance
- .12 ☐ Energy Supplier
- .13 ☐ Trade Associations
- .14 ☐ Other, specify ____________________

16. Has present work/job role any connection to innovation in question and if so how?

____

____

____

17. When did you join them ____

18. Did you work with or assist any (other) company/association/group that had any involvement with the innovation in question.

.1 ☐ YES .2 ☐ NO

19. What was the nature of the companies/association/groups involvement?

____

____

20. What was your role in the company/association/group?

____

____

When did you join? __________________ When did you leave? ____________________________

21. Specifics of your involvement

	INVOLVEMENT					LOCATION
GENERAL JOB RATE	INITIAL	EARLY	LATER	DIRECT	SENIOR PLAYER	ATLANTIC, QUEBEC, ONTARIO PRAIRIES, B.C. OTHERS
.1 Research & Dev.						
.2 Production						
.3 Distribution						
.4 Regulatory						
.5 Evaluation & Test						
.6 Communications (promotion: for & against)						
.7 Use (specify)						

22. Is the Company involved in any other products/materials/processes associated with the innovation under study? .1 ☐ YES .2 ☐ NO

What are they? ______________________________

____

____

23. Are you involved in any other products/materials/processes associated with innovation under study? .1 ☐ YES .2 ☐ NO

What are they? ______________________________

____

____

DATA ON INNOVATION

24. Describe the Innovation in Respondents Words: ______________________________

____

____

____

____

____

25. Classify Innovation As:

.1 ☐ Building Material, .2 ☐ Building Product, .3 ☐ Construction Technique,

.4 ☐ Construction Equipment, .5 ☐ Building Equipment, .6 ☐ Associated and Related Services

.7 ☐ Business Management

26. Source of Innovation

.1 ☐ Private Researcher or Research Group, .2 ☐ Manufacturer,

.3 ☐ Public Sector Research/University/Government, .4 ☐ Construction Industry (Private Sector)

.5 ☐ Not Known

27. Geographic Origin

.1 ☐ Canada .2 ☐ Atlantic .3 ☐ Quebec .4 ☐ Ontario .5 ☐ Prairies .6 ☐ B.C.

.7 ☐ U.S.

.8 ☐ Other (Name Country) ____________________

Development Dates

28. Beginning of R & D process (approximate if unknown exactly) ____________________

29. Beginning of Marketing at Source ____________ 30. In Canada ______ ____________

31. Other relevant dates: ____________________ ____________________

32. What do you think was the Basic Motivation for the Innovation:

.1 ☐ To fulfill a clearly defined market need derived from dissatisfaction with the status quo and acknowledged before the Innovation was created,

____

____

.2 ☐ To produce a product which the Innovator thinks the market will want, once it understands the Innovation's benefits.

____

____

.3 ☐ To produce a product to satisfy regulatory requirements.

____

____

33. To the best of your knowledge which of the following activities were carried out in the implementation of the Innovation.

.1 Basic Research ☐ ____________________

____

.2 Applied Research ☐ ____________________

____

.3 Feasibility Studies ☐ ____________________

____

.4 Market Studies ☐ ____________________

____

4

.5 Prototype Construction, Testing, Evaluation ☐

.6 Field Market Testing ☐

.7 Product Enhancement and Improvement ☐

.8 Utilization of Government Grant Programs ☐

.9 Extensive Use of Private Capital ☐

.10 Use of Government Non Capital Resources ☐

.11 Manufacturing: By Innovation Organization ☐ by 3rd Party Manufacturer ☐

.12 Regulatory Evaluation ☐

.13 Market Promotion: ☐ Extensive ☐ Not Extensive

.14 Financial/Business Planning ☐

.15 Continued Market Analysis ☐

34. List organization(s) presently involved with developing/using the innovation

35. Preception of size of these organization(s):

ORGANIZATION	SIZE (LARGE, SMALL)

36. Are any of these organizations considered to be newcomers to the field involving the innovation under study? ______________________ Why? ______________________

____

____

37. Do any of these organizations lend credibility to the innovation due to their successful experience with other products or ideas? ______________________

____

Give Example(s) ______________________________

____

____

38. The introduction and eventual acceptance or non-acceptance of the innovation under study is carried out through the various industry components that constitute the low rise residential construction industry. Which of the following industry components do you think have played a major role in either helping or hindering the introduction and acceptance of this innovation:

INDUSTRY COMPONENTS	STRONGLY HELP INTRO	STRONGLY HINDER INTRO	LITTLE IMPACT	STRONGLY HELP ACCEPT.	STRONGLY HINDER ACCEPT.	LITTLE IMPACT
.1 House Buyer						
.2 Builder/General Contractors/Developer						
.3 Subtrades* ______________						
______________						
______________						
.4 Architect or ________ Engineer						
.5 Building Material Supplier						
.6 Building Materials or Product Manufacturer						
.7 Municipalities						
.8 Other Public Interest Organizations						
.9 Financial						
.10 Real Estate						
.11 Insurance						
.12 Energy Supplier						
.13 Trade Associations						
.14 Other, Specify						

*.1 concrete, .2 framing, .3 finish carpentry, .4 roofing, .5 siding, .6 plumbing, .7 electrical, .7 heating, .9 flooring, .10 drywall

39. The innovation under consideration has an affect on the use of capital, labour and energy in low rise residential construction. There are a number of factors involved in assessing its affect which relate both to general market preferences and to competing technologies, products, materials, etc. For each of the following factors identify your perception of todays market preference for that factor within the general field of which the innovation is a part. Then determine with respect to each of these factors whether the innovation makes a positive or negative contribution. Also with respect to each of the factors determine which industry components directly benefit the most from the use of the innovation and which industry component directly benefits the least.

Factors involved in assessing the use of capital, labour and energy:

.1 DECREASED CONSTRUCTION TIME: The innovation allows the period of construction to be decreased from that using previously existing methods.

.2 DECREASED LABOUR TIME: The innovation decreases directly and/or indirectly the overall amount of labour involved in the project from that using previously existing methods.

.3 DECREASED LABOUR SKILLS LEVEL: The innovation does not require the same level of labour skills as did previously existing methods.

.4 DECREASED MATERIAL COSTS: The innovation decreases directly and/or indirectly the overall cost of materials involved in the project from that using previously existing methods/materials.

.5 DECREASED LIFE CYCLE COSTS: The innovation leads to a decrease in total life cycle costs.

.6 DECREASED FIRST COSTS: The innovation leads to a decrease in first costs for the total project.

.7 IMPROVED ENERGY PERFORMANCE: The innovation improves the utilization of energy, including factors such as reduced energy consumption, or utilization of multiple sources of energy, or the utilization of previously unutilizable energy sources.

.8 IMPROVED SAFETY: The innovation improves the safety of the occupant or worker.

.9 IMPROVED APPEARANCE: The innovation leads to an improved appearance in all or some aspects of the project.

.10 IMPROVED COMFORT LEVEL: The innovation makes the project in some ways more comfortable for the occupant or worker.

.11 IMPROVED DURABILITY: The innovation makes all or some of the project more durable than by using previously existing methods and/or materials.

FACTOR	GENERAL MARKET PREFERENCE IN THE FIELD OF THE INNOVATION - FAVORABLE, O UNFAVORABLE, UNKNOWN	CONTRIBUTION OF THE INNOVATION TO THE FACTOR +, 0, -, UNKNOWN	INDUSTRY COMPONENTS (FROM QUESTION 37) MOST BENEFIT	INDUSTRY COMPONENTS (FROM QUESTION 37) LEAST BENEFIT
DECREASED: .1 Construction Time				
.2 Labour Time				
.3 Labour Skill Level				
.4 Material Cost				
.5 Life Cycle Cost				
.6 First Cost				
IMPROVED: .7 Energy Performance				
.8 Safety				
.9 Appearance				
.10 Comfort Level				
.11 Durability				

40. The acceptance or non acceptance of the innovation under study is affected by perceptions of the benefits it confers to the industry component that uses it. For each of the following properties identify those industry components (if any) which would either perceive great value in the property and those which would perceive no value in the property.

PROPERTIES:

.1 RELATIVE ADVANTAGE: The advantages of the innovation are perceived to be visible, large, immediate to the industry component.

.2 COMPATIBILITY: The innovation is perceived to be consistant with current practice and experience of the industry component.

.3 REDUCED COMPLEXITY: The innovation is no more complex than past experience and does not require significantly higher levels of skill or knowledge of the industry component.

.4 TRIALABILITY: The innovation can be tried relatively easily and conveniently by the industry component.

.5 COMMUNICABILITY: The innovation can be both relatively easily understood by the industry component and explained to others.

PROPERTY	INDUSTRY COMPONENTS (from Question 37)	
	GREATEST VALUE	LEAST VALUE
.1 Relative Advantage		
.2 Compatibility		
.3 Reduced Complexity		
.4 Trialbility		
.5 Communicability		

41. Can the innovation be utilized by itself or must it be part of a system or package?

42. Can the innovation being considered be easily incorporated into the present structure of the industry?

.1 ☐ YES .2 ☐ NO

43. The utilization of the innovation in question involves a variety of risks. These risks affect each of the various components of the industry differently, and they vary in time. For each of the types of risk listed suggest which industry components take the greatest risk and which industry components take the least. Do this for both the time of the innovations introduction and the present.

TYPE OF RISK:

- .1 FINANCIAL RISK: The use of this innovation would put a strain on the financial resources of the industry component using it.
- .2 PRODUCT RISK: The innovation may not perform as expected by the industry component.
- .3 COMPETITIVE RISK: The choice of this innovation over available alternatives may not be acceptable to the buyer of the industry components work/product.
- .4 INFORMATION RISK: The information available on the innovation may not be reliable, or there is not sufficient information available.
- .5 MARKET RISK: There may not be any real market demand for the innovation.
- .6 MANAGEMENT RISK: There may be a need for the industry component using it to make adjustments in his organization in order to use the innovation.
- .7 STRATEGIC RISK: The use of this innovation may not be in the long term the best way of utilizing the resources of the industry component using it.
- .8 REPUTATION RISK: The use of the innovation may negatively affect the reputation of the the industry component using it.
- .9 LIABILITY RISK: The use of the innovation may increase the industry component's legal liabilities.

	INDUSTRY COMPONENTS FROM QUESTION 37					
	INTRODUCTION OF INNOVATION			PRESENT TIME		
TYPE OF RISK	GREATEST RISK	LEAST RISK	UNKNOWN	GREATEST RISK	LEAST RISK	UNKNOWN
.1 FINANCIAL RISK						
.2 PRODUCT RISK						
.3 COMPETITIVE RISK						
.4 INFORMATION RISK						
.5 MARKET RISK						
.6 MANAGEMENT RISK						
.7 STRATEGIC RISK						
.8 REPUTATION RISK						
.9 LIABILITY RISK						

44. Your perception of the level of success of innovation at this point in time:

	Unsuccessful	Successful	Yet to be Determined
1. With respect to number of actual users compared to total number of potential users.			
2. With respect to its rate of production compared to production in competing products.			
3. With respect its qualities relative to the standards in the field.			

45. Is there anyone else that would be a good source of information for this project? ____________

____

____

APPENDIX B

INTERVIEW GUIDE FOR BUILDERS

THORKELSSON ARCHITECTS LTD./MAYELL ARCHITECTS LTD.
PROJECT: TECHNOLOGY TRANSFER IN RESIDENTIAL CONSTRUCTION INDUSTRY
PROJECT NO.: 741

INTERVIEW SET UP AND PRELIMINARY INFORMATION: Builders Only

1. Name of Person to be Interviewed: ____________________

2. Present Place of Work: ____________________

3. Address: ____________________

4. Title: ____________________

5. Short Job Description: ____________________

6. Background in Residential Construction: ____________________

7. Education: High School .1 ☐ Tech. School .2 ☐ University .3 ☐

8. Specific Training in Construction Practices: ____________________

____

9. Number of Years in Residential Construction: ____________________

10. How many housing units have you been directly involved in construction per year over past 5 years? ______________ Units.

11. Where were most of these units built? .1 ☐ Rural, .2 ☐ Towns,
.3 ☐ Small Cities (100,000 Pop. or less)
.4 ☐ In or close to Large Urban Centre

DATA ON INNOVATIONS:

12. Listed are a number of innovations that have been incorporated into low rise residential construction over the years. Indicate when and why you first used the innovation. If you don't know about the innovation insert NK. Also indicate whether you would follow a house buyers recommendation on the product, whether you would allow a subtrade to use it if they chose to and finally where you think it stands in general market acceptance today.

INNOVATION	FIRST USED INNOVATION WHEN	WOULD ACCEPT HOME PURCHASER RECOMMENDATION	WOULD ALLOW SUBTRADE USE	PRESENT MARKET ACCEPTANCE			
				HIGH	MED.	LOW	NONE
.1 Oriented Strand Board							
.2 Medium Density Fiberboard							
.3 Preserved Wood Foundations							
.4 Rigid foam Insulation and Framing System							
.5 Drywall Clips							
.6 Air Tight Drywall System							
.7 Prefab. Wood "I" Joists							
.8 "75" Stressed Skin Panel System							

13. For each innovation you have used give reason for first use.

14. Of the innovations listed you have indicated that you use some and not others. Indicate the degree of use you or your trades make of each innovation in your projects.

INNOVATION	USE A LOT	USE EQUAL TO OTHER COMPETING PRODUCTS	VERY LITTLE	NOT AT ALL
.1 Oriented Strand Board				
.2 Medium Density Fiberboard				
.3 Preserved Wood Foundations				
.4 Rigid foam insulation and Framing System				
.5 Drywall Clips				
.6 Air Tight Drywall System				
.7 Prefab. Wood "I" Joists.				
.8 "7S" Stressed Skin Panel System				

15. Each of the Innovations listed is expected to contribute to construction process in some fashion. For each of the innovations you are familiar with indicate your perception of how it either contributes to (+), does not contribute to (o), or detracts from (-) the following factors involved in the construction process. If you have no idea of its contribution use NK.

Factors involved in the construction process that the innovation contributes or does not contribute to:

.1 DECREASED CONSTRUCTION TIME: The innovation allows the period of construction to be decreased from that using previously existing methods.

.2 DECREASED LABOUR TIME: The innovation decreases directly and/or indirectly the overall amount of labour involved in the project from that using previously existing methods.

.3 DECREASED LABOUR SKILLS LEVEL: The innovation does not require the same level of labour skills as did previously existing methods.

.4 DECREASED MATERIAL COSTS: The innovation decreases directly and/or indirectly the overall cost of materials involved in the project from that using previously existing methods/materials.

.5 DECREASED LIFE CYCLE COSTS: The innovation leads to a decrease in total life cycle costs.

.6 DECREASED FIRST COSTS: The innovation leads to a decrease in first costs for the total project.

.7 IMPROVED ENERGY PERFORMANCE: The innovation improves the utilization of energy, including factors such as reduced energy consumption, or utilization of multiple sources of energy, or the utilization of previously unutilizable energy sources.

.8 IMPROVED SAFETY: The innovation improves the safety of the occupants or workers.

.9 IMPROVED APPEARANCE: The innovation leads to an improved appearance in all or some aspects of the project.

.10 IMPROVED COMFORT LEVEL: The innovation makes the project in some ways more comfortable for the occupants or workers.

.11 IMPROVED DURABILITY: The innovation makes all or some of the project more durable than by and using existing methods and/or materials.

INNOVATION	.1 DECREASED CONSTRUCTION TIME	.2 DECREASED LABOUR TIME	.3 DECREASED LABOUR SKILLS LEVEL	.4 DECREASED MATERIAL COSTS	.5 DECREASED LIFE CYCLE COSTS	.6 DECREASED FIRST COSTS	.7 IMPROVED ENERGY PERFORMANCE	.8 IMPROVED SAFETY	.9 IMPROVED APPEARANCE	.10 IMPROVED COMFORT LEVEL	.11 IMPROVED DURABILITY
.1 Oriented Strand Board											
.2 Medium Density Fiberboard											
.3 Preserved Wood Foundations											
.4 Rigid foam Insulation and Framing System											
.5 Drywall Clips											
.6 Air Tight Drywall System											
.7 Prefab. Wood "I" Joists.											
.8 "TS" Stressed Skin Panel System											

16. Each of these innovations will be perceived to confer benefits to the user of the innovation which can be assessed in a number of ways. For each innovation you are familiar indicate whether you perceive the innovation to have for you a positive value (+), no value (o), or a negative value (-), for each of the properties listed below:

PROPERTIES:

.1 RELATIVE ADVANTAGE: Advantages of the innovation are perceived to be visible, large, immediate for you or your business.

.2 COMPATIBILITY: The innovation is perceived to be consistant with your current practice and experience.

.3 REDUCED COMPLEXITY: The innovation is no more complex than past experience and does not require significantly higher levels of skill or knowledge.

.4 TRIALABILITY: The innovation can be tried relatively easily and conveniently by yourself.

.5 COMMUNICABILITY: The innovation can be both relatively easily understood and explained to others.

INNOVATION	.1 RELATIVE ADVANTAGE	.2 COMPATIBILITY	.3 REDUCED COMPLEXITY	.4 TRIALABILITY	.5 COMMUNICABILITY
.1 Oriented Strand Board					
.2 Medium Density Fiberboard					
.3 Preserved Wood Foundations					
.4 Rigid foam insulation and Framing System					
.5 Drywall Clips					
.6 Air Tight Drywall System					
.7 Prefab. Wood "I" Joists.					
.8 "7S" Stressed Skin Panel System					

17. To use each of these innovation involves some risk on your part. For those innovations that you are familiar with indicate what kinds of risks you think are involved in you using these innovations, and whether this risk is heavy (H), medium (M), or light (L).

TYPE OF RISK:

.1 FINANCIAL RISK: The use of this innovation would put a strain on your financial resources.

.2 PRODUCT RISK: The innovation may not perform as you expect.

.3 COMPETITIVE RISK: The choice of this innovation over available alternatives may not be acceptable to your buyer.

.4 INFORMATION RISK: The information available on the innovation may not be reliable, or there is not enough information available.

.5 MARKET RISK: There may not be any real market demand for the innovation.

.6 MANAGEMENT RISK: There may be a need for you to make adjustments in your organization in order to use the innovation.

.7 STRATEGIC RISK: The use of this innovation may not be in the long term the best way of utilizing your resources.

.8 REPUTATION RISK: The use of the innovation may negatively affect the reputation of your business (and yourself).

.9 LIABILITY RISK: The use of the innovation may increase your legal liabilities.

INNOVATION	FINANCIAL RISK	PRODUCT RISK	COMPETITIVE RISK	INFORMATION RISK	MARKET RISK	MANAGEMENT RISK	STRATEGIC RISK	REPUTATION RISK	LIABILITY RISK
.1 Oriented Strand Board									
.2 Medium Density Fiberboard									
.3 Preserved Wood Foundations									
.4 Rigid foam Insulation and Framing System									
.5 Drywall Clips									
.6 Air Tight Drywall System									
.7 Prefab. Wood "I" Joists.									
.8 "7S" Stressed Skin Panel System									

18. For those that you use a lot specific reasons not noted in earlier questions.

19. For those that you use a little give specific reasons not noted in earlier questions.

APPENDIX C

CASE STUDIES

INTRODUCTION

Eight innovations were examined in this study. They are examples of products or systems which have or could have significance to the Alberta economy while furthering the quality of low rise residential construction. The innovations chosen were:

1. Oriented Strand Board (O.S.B.).
2. Medium Density Fiberboard (M.D.F.).
3. Preserved Wood Foundations (P.W.F.).
4. Rigid Foam Insulation and Framing System (Nascor System).
5. Drywall Clips.
6. Air Tight Drywall Approach (A.D.A.).
7. Prefab Wood "I" Joists (Wood "I"'s).
8. 7-S Stressed Skin Panel System (7-S System).

Each of the innovations were discussed with a proponent of the innovation or someone close to the innovation's development. The purpose of these interviews was to develop an overview of the present status of the innovation, how it got to that position and what seems to be helping or hindering its further advance in the market place. These discussions were analyzed to identify measures to facilitate technology transfer and the adoption of innovative methods and products in the housing industry.

The interviews were guided by the interview format shown on Appendix A. The interview topic areas were developed in conjunction with the topic areas devised by the consultants to a C.M.H.C. study on innovation and technology transfer in residential low rise construction.

The interview guide consists of a series of questions that derive from a model of the technology transfer process, and has five major subject areas:

1. the activities the innovator undertook to bring his innovation from an idea to market,

2. the industry components which helped or hindered efforts to bring it to market,

3. the significant contributions of the innovation to the construction process and the quality of the built product,

4. the significant benefits the user obtained from using the innovation that would encourage or not encourage him to use it, and

5. the perceived risks involved in using the innovation.

In the discussion of these subject areas, there was a effort to distinguish between "innovation" and "invention". Innovation was defined as a modification or refinement of an invention or of a common material or practice.

CASE STUDY: ORIENTED STRAND BOARD (O.S.B.)

INFORMATION SOURCE

The person interviewed specifically on O.S.B. has been involved with the manufacturer since the preparation of feasibility studies and the construction of the first unit in Alberta in 1982. He has worked in many facets of the plant operation and has also been involved heavily in marketing.

1. DESCRIPTION AND PRESENT STATUS OF ORIENTED STRAND BOARD

O.S.B. is a structural composite panel made of aspen and/or poplar chips bonded with resins. The wood strands are oriented in layers much like plywood and give the same strength as plywood. For the purposes of this study O.S.B. is classified as a building material.

The primary source of the innovation was not known to the respondent. However it is known that the original research into a wafer board began in the U.S. in the 1950's. O.S.B. was first manufactured in Europe in 1978. The material was first manufactured in Alberta and Canada in 1983.

Two motives led to this innovation coming to Alberta. The first was the need to find a cost effective alternate to traditional plywood which is becoming poorer in quality and higher in price due to the reduced availability of good peeler logs. The second was to find a use for the large stands of aspen and poplar trees that grow in Alberta. A cost competitive product with the structural properties of plywood O.S.B. was expected to have ready market acceptance.

2. TRANSFER ACTIVITIES CARRIED OUT TO DATE ON O.S.B.

The respondent thought the following activites have taken place in the implementation of O.S.B.

.1 BASIC RESEARCH

The original research in the U.S. was thought to be basic in that it involved experiments in fiber bonding and resultant shear and compression testing and durability tests. Much of this work was done in university and industrial laboratories.

.2 APPLIED RESEARCH, PROTOTYPE CONSTRUCTION, PRODUCT ENHANCEMENT AND IMPROVEMENT

Much was done in the U.S. and Europe, particularly in the design of manufacturing equipment for O.S.B. which utilized the skills of engineers and industrial technicians. Local applied research in plant lab facilities has focused on setting up quality controls, and testing and modifying the material in order to satisfy the same set of structural requirements for plywood.

A number of prototypes have been developed to evaluate variations of the material and examine new ways of using the material in new applications. Test work has been done by Alberta Research Council, private testing labs and the Canadian Council of Forest Industries, to obtain regulatory approvals.

.3 FEASIBILITY STUDIES

A major feasibility study was done by professional consultants to determine whether O.S.B. could be manufactured economically in Alberta. This study formed the basis for establishing mills at Edson and Drayton Valley.

.4 MARKET STUDIES, CONTINUED MARKET ANALYSIS AND MARKET PROMOTION

The feasibility studies above in Item 3 also included market studies.

It has always been a general policy of the manufacturer to look for new uses for O.S.B., and for ventures that produce added value to the material. O.S.B. is rapidly becoming a "commodity" with no one manufacturer controlling the market and with prices fluctuating on the basis of demand and supply. It is thought that this price variability can be avoided by the introduction of new value-added product lines.

Some direct marketing is done by participating in local home shows but most is done by material wholesalers. Most of the material is sold in Western Canada and U.S. with the majority of the sales outside of Alberta.

.5 FIELD MARKET TESTING

"Truck Load" samples have been supplied to selected builders in order to see how various applications perform in the field, and to promote market acceptance.

.6 UTILIZATION OF GOVERNMENT GRANT PROGRAMS

Small grants have been utilized for structural evaluation and testing for code approval.

.7 USE OF GOVERNMENT NON-CAPITAL RESOURCES

Alberta Economic Development and Alberta Forestry Lands and Wildlife have provided assistance.

.8 EXTENSIVE USE OF PRIVATE CAPITAL

Upwards of $120 Million have been spent on capital and start-up costs to date.

.9 MANUFACTURING

O.S.B. is not a proprietary or patented material and is produced in plants around the world.

.10 REGULATORY EVALUATION

The material has full regulatory approval as an alternate to plywood in Canada and United States.

.11 FINANCIAL/BUSINESS PLANNING

Professional resources were used to prepare extensive business plans.

SUMMARY OF CURRENT STATUS

This innovation is in the marketing stage. New plants are coming on stream every year in many parts of the world. Present production in Alberta is over 46 million square meters of 10 mm O.S.B. per year and many other waferboard mills in Canada are converting to produce a similar product.

At this point in time O.S.B. must be considered a success. It may be produced to excess leading to a decrease in prices and pushing marginal producers to the wall. Many waferboard plants are converting to produce O.S.B. because of its superior properties over waferboard.

3. FACTORS AFFECTING TECHNOLOGY TRANSFER

.1 MARKET PERCEPTION IN THE FIELD OF PANEL MATERIALS AND HOW O.S.B. FITS IN THE PERCEPTION

Most houses use a panel type material such as plywood for sheathing and subflooring. The switch to plywood panels from boards took place years ago and appears to be due mainly to the resulting reduction in construction time and labour cost. Today most people feel the use of panels is quite acceptable in construction and do not see an alternative panel resulting in any great improvement. All things being equal, however, a panel that is cheaper than plywood would be desirable. The general trend is for quality plywood prices to increase which supports O.S.B.

O.S.B. has been designed to have the same general properties as plywood but at a lower price. However, it does have a few drawbacks. The hardness of the resin makes it more difficult to nail. In certain weather conditions it is more slippery than plywood, making it more hazardous to use during construction. It generally looks like waferboard, another type of chipboard sheathing which does not perform like plywood and has a poor reputation.

.2 INDUSTRY COMPONENTS INVOLVED

O.S.B. is a replacement material. It is aimed directly at replacing plywood in the residential construction market by providing a material of equivalent properties at lower cost. This pits O.S.B. directly against the plywood industry and their trade associations who wish to see it grouped with the inferior waferboard. It has obtained regulatory approvals everywhere as a substitute for plywood although not without a fight in areas where the plywood industry is strong. It continues to receive positive support from architects and engineers, building material suppliers and builders in areas where waferboard is not widely known.

.3 FACTORS AFFECTING THE DIFFUSION OF O.S.B.

The factors that are helping the diffusion of O.S.B. are:

.1 The lower cost of O.S.B. in relation to plywood (relative advantage).

.2 The ease with which it can substitute for existing panel material (compatability, trialability).

The factors that are hindering the diffusion of O.S.B. are:

.1 The confusion between the different types of waferboard. O.S.B. looks like the original waferboard which is an inferior product without the same structural properties (reduced communicability, information risk, product risk).

The factors affecting diffusion focus mainly on the manufacturer. The manufacturer of O.S.B. is in a situation where its chief competitor, the plywood industry, actively works to blur the distinction between O.S.B. and the lower quality waferboards in order to maintain the image of plywood's superior structural properties. Nevertheless many plywood manufacturers are getting into O.S.B. production, simply because their supply of peeler logs is declining while the stock of small trees useful for O.S.B. remains large. An additional factor further blurring O.S.B. waferboard distinction is that many of the waferboard manufacturers are also upgrading their products to produce a product called oriented waferboard (O.W.B.) which is better than waferboard but still inferior to O.S.B.

While all this suggests a good future for O.S.B., its future is more assured in markets where the original waferboard was never a factor. In the prairie provinces where aspen based waferboard was introduced into the market in the 1960's, waferboard has aquired a "cheap" image: a low quality product at a low price. Part of this image is due to problems the waferboard industry has had in maintaining quality, particularly due to the fact that manufacturers are not required to have quality control. Because O.S.B. looks almost identical to waferboard, it is perceived by builders familiar with waferboard to be poor quality which they think won't be accepted by house buyers.

4. POSSIBLE MEASURES THAT MIGHT HELP THE DIFFUSION OF O.S.B.

To counteract the image problem the manufacturer has begun to aim its promotions directly to home buyers through home shows and information clearly outlining the distinction between waferboard and O.S.B. These presentations show O.S.B. used attractively in a variety of ways. It also clearly stamps its board as O.S.B. to distinguish it from waferboard at the construction site.

The manufacturer would appreciate help from government in the area of standards and quality control. It believes that overall performance standards instead of material designation standards would help rid the biases favouring plywood over O.S.B. which are inherent in the present standard derived from plywood. It also believes that any manufacturer that produces a product required to have dependable structural characteristics should have a monitored quality control program which at present is not required in Canada. These actions would help to clarify the similarities and distinctions between the various types of panels, and increase buyer confidence in O.S.B., particularly in the Prairies.

CASE STUDY: MEDIUM DENSITY FIBERBOARD (M.D.F.)

INFORMATION SOURCE

The persons interviewed specifically on M.D.F. have been involved with it since 1983 when the first feasibility studies for Canadian manufacture were done.

1. DESCRIPTION AND PRESENT STATUS OF MEDIUM DENSITY FIBERBOARD

M.D.F. is a panel board made of wood fibers which have first been pulped, then mixed with resin and compressed into a sheet of varying dimensions and thicknesses for use in finish millwork, cabinetry and furniture. For the purposes of this study it has been classified as a building material.

The primary source of the innovation is thought to be private research probably conducted by or sponsored by large forest based industries in the early 1970's. Its place of origin is thought to be the eastern United States. The original motivation appears to be set by both the increasing market desire for a material better than particle board and a desire for the forest industry to find more uses for what was essentially wood waste. The motivation for starting manufacture in Canada in 1986 was a commitment by a large corporation to government to find new uses for local wood resources.

2. TRANSFER ACTIVITIES CARRIED OUT TO DATE ON M.D.F.

The respondents thought the following activities have taken place in the implementation of M.D.F.

.1 BASIC RESEARCH

M.D.F. is a highly technical product, almost at the same scale as paper. Considerable research in fully equipped laboratories has gone into pulping and fiber strengths and similar issues during its development in the U.S. There has been little additional research done in Canada.

.2 APPLIED RESEARCH, PROTOTYPE CONSTRUCTION, TESTING AND EVALUATION

A large amount of research has gone into investigation of the properties of the finished materials. The process and equipment has also been researched by European equipment manufacturers. Little has been done in Canada so far, but there is increasing effort by the Canadian manufacturer to start to improve the material now that they are familiar with the product and its manufacture. Some experimentation is presently being done by the Alberta Research Council under contract.

.3 FEASIBILITY STUDIES, MARKET ANALYSIS AND PROMOTION

Though little is known about original studies done before introduction in the U.S. major studies by qualified professional firms were completed before its introduction into Canada. Market analysis and promotion is primarily to large wholesalers and brokers, which presumably market to the retail industry. Most of the material is used by the furniture industry, and a large portion is sold into foreign markets. There is at present no promotion to the residential construction industry.

.4 FIELD MARKET TESTING

With the view to inducing them to switch, the first Canadian product was marketed to users who were importing M.D.F. from elsewhere.

.5 UTILIZATION OF GOVERNMENT GRANT PROGRAMS

A Federal Government grant was utilized to offset part of the capital cost of the power and heating plant of the M.D.F. manufacturing facility. This grant was available because the plant used waste wood, not petroleum based fuel.

.6 USE OF GOVERNMENT NON CAPITAL RESOURCES

The manufacturer is partially owned by the provincial government and consequently has reasonable access to and help from all levels of provincial government departments.

.7 EXTENSIVE USE OF PRIVATE CAPITAL

Most of capital used to date came from private sources.

.8 MANUFACTURING

At present all manufacturing of M.D.F. is in Alberta and Quebec where a competing company has started to manufacture and market M.D.F.

.9 REGULATORY APPROVALS

The material has full regulatory approval.

.10 FINANCIAL/BUSINESS PLANNING

The manufacturer is a large corporation and functions using fully professional financial and business planning teams.

SUMMARY OF CURRENT STATUS

The present status of M.D.F. is the marketing stage with the Alberta plant running at full capacity. Most of the material is shipped to eastern Canada or to foreign countries primarily for use by furniture manufacturers. At present there are approximately 20 M.D.F. manufacturing plants around the world with two in Canada and they have captured up to 20% of the industrial panel board industry. These numbers suggest that M.D.F. is a successful innovation.

3. FACTORS AFFECTING TECHNOLOGY TRANSFER

.1 MARKET PERCEPTION IN THE FIELD OF PANEL BOARD FOR FINISH CARPENTRY AND MILLWORK.

Finish carpentry and millwork utilize good quality panel boards such as sanded plywoods. Good quality plywoods have become increasingly expensive and a more economical option taking its place has been particle boards. Particle board however does not lend itself to conventional millwork techniques and if not utilized in exactly the right way will result in inferior quality millwork. Consequently there is a general market desire for a panel board that is more economical than good quality plywood but without the drawbacks of particle board.

M.D.F. solves most of the problems associated with particle board. It is also in some respects an improvement over plywood and at a lower cost. It decreases construction time and labour time because there is less fitting and finishing of cuts. It can be machined and milled to finer tolerances and finish than can either plywood or particle board. It improves life cycle cost with respect to painted plywood in that it does not "check" like plywood.

Its most significant unfavorable characteristic is that, like particle board, the resin used is formaldehyde based. Although emissions are reduced when M.D.F. is coated, there are considerable emissions during cutting and fabricating.

.2 INDUSTRY COMPONENTS INVOLVED

M.D.F. is a material intended to replace existing materials on the market, primarly high quality plywoods and particle boards used as millwork and cabinet work substrates. It will also replace wood in instances where the end grade of the wood is a problem in finishing. Its main proponents are the manufacturer, and the furniture industry, which presently use most of the material. Builders and finish carpenters who have used it are in favor of it. Other components of the residential industry do not play a significant role in determining the use of the product. It could be expected that the particle board manufacturers would hinder the diffusion of M.D.F. but most appear to recognize the limitations of particle board in millwork applications and are moving toward the manufacture of M.D.F. as well.

.3 FACTORS AFFECTING THE DIFFUSION OF M.D.F.

The factors that are helping the diffusion of M.D.F. are:

.1 Its ease of use in finish carpentry and millwork (compatibility, reduced complexity, trialability).

.2 Its better finished qualities and lower cost than quality plywoods (relative advantage).

The factors that hinder the diffusion of M.D.F.

.1 The use of formaldehyde based resins, although this is also a factor in other panel board materials (decreased safety).

.2 The lack of knowledge of the material by builders and finish carpenters (information risk, product risk).

.3 The higher cost of M.D.F. over particle board.

The pro and con factors affecting diffusion focus primarily on the manufacturer. At this time the manufacturer has focused its attention on the furniture industry where its first efforts have been to replace imported M.D.F. with its own. In this regard it has been successful. But it recognizes that as other manufacturers start production the market will tighten up. The manufacturer has not at this time realized that a considerable amount of the material could be used in houses although a small number of builders have. Therefore no effort is being made to expand the residential construction market except where a builder or a building material supplier might see some possibilities.

4. POSSIBLE MEASURES THAT MIGHT HELP THE DIFFUSION OF M.D.F.

M.D.F. appears to be a product in waiting in so far as the residential construction market is concerned. The manufacturer has relatively little need to sell his product outside the furniture industry. At the same time a small number of builders are gradually uncovering its uses in residential construction at their own pace. It would appear that the rate of diffusion will coincide with the builder's interest until the manufacturer faces strong competition in supplying the furniture manufacturing industry and refocuses his interest to supply the residential housing market. It also appears that there is no need for further government involvement.

CASE STUDY: PRESERVED WOOD FOUNDATIONS (P.W.F.)

INFORMATION SOURCE

The persons interviewed specifically on P.W.F. either design P.W.F. or market P.W.F. They have been involved with P.W.F. since the late 1970's, and between then and now they have been involved in the installation of over 8,000 preserved wood foundations.

1. DESCRIPTION AND PRESENT STATUS OF PRESERVED WOOD FOUNDATIONS

P.W.F. is a system of constructing a foundation out of pressure preservative treated wood members using modified framing techniques. For purposes of the study it is classified as both a building product and a construction technique since it has special products (preserved wood) and also represents a technique since it is assembled on site in accordance with a specific foundation design.

The primary source of the innovation is not known but is thought to have originated in government-sponsored research. One source of the innovation is thought to be United States although some early research was done in the 1950's in Canada (Mark Series Homes - Rockcliffe, Morinville). It is not a specific invention but a building approach that is made practical with the availability of preserved wood at a reasonable price. P.W.F. is not a proprietary product so comes with little standardized instructions, plans, or service except from those who think they can make a business of it.

The original motivation for the innovation is thought to be the desire for the manufacturers and suppliers of preserved wood to find new uses for their material. With the development of CCA (chromium, copper, arsenic) preservatives, the manufacturers of the treated wood believed that they had a material that would be accepted as an alternative to concrete in the construction of residential foundations.

2. TRANSFER ACTIVITIES CARRIED OUT TO DATE ON P.W.F.

The respondents thought the following activities have taken place in the implementation of P.W.F.

1. BASIC RESEARCH

P.W.F. itself does not involve basic research. Formalized research has been done by the manufacturers in testing the longevity and dependability of the preservative-treated wood materials.

2. APPLIED RESEARCH, PROTOTYPE CONSTRUCTION, PRODUCT ENHANCEMENT AND IMPROVEMENT

A number of test basements have been constructed, but generally such research appears to be localized. A number of studies are currently being done evaluating P.W.F.'s which have been in place for a number of years. There is some question whether this information is being disseminated.

There are a number of engineering specialists in Alberta involved in evaluating P.W.F. and designing new construction details and ways of putting a P.W.F. together. These firms have taken advantage of the Alberta Building Code provision which requires P.W.F. to be designed by an engineer.

3. FEASIBILITY STUDIES

These have been done mostly by the manufacturers mainly regarding materials, but are not readily available to potential buyers.

4. MARKET STUDIES, CONTINUED MARKET ANALYSIS AND MARKET PROMOTION

These have been done mostly by the manufacturers, but are not readily available to potential buyers. There appears to be no clear understanding of the nature of market preferences or concerns and how these could be addressed by P.W.F. suppliers.

Very little effort is spent in promoting P.W.F. except as an adjunct by manufacturers trying to sell preserved wood. P.W.F. constitutes a very small component of the total preserved wood market so there is little motivation to carry out focused marketing on this product, although some brochures are available through trade associations. The concrete industry criticizes P.W.F. through newletters and brochures. The most successful market promotions done in Alberta are those done by retail lumber outlets who sell material packages including P.W.F. to small town and rural buyers where concrete prices are high.

5. FIELD MARKET TESTING

Field market testing was initially attempted by local firms that tried to become specialists in the supply of materials for and in the construction of P.W.F. They prepared design details, brochures, etc. which were sent to building material suppliers, builders, architects and engineers. They also tried to get P.W.F.'s into home parades. Their marketing efforts made comparisons between P.W.F. and concrete foundations, emphasizing the additional work thought to be necessary to produce an equivalent foundation using concrete, such as strapping the concrete wall so it can be insulated, in order to justify the additional cost of P.W.F.

6. UTILIZATION OF GOVERNMENT ASSISTANCE PROGRAMS

Funds have been available for studies evaluating P.W.F. Little if any funds are available for direct application.

7. USE OF PRIVATE CAPITAL

The bulk of the funds have been spent on pressure treating technology and the marketing of materials. Little has been spent on developing and marketing P.W.F. itself, in relation to the size of the potential market.

8. USE OF GOVERNMENT NON-CAPITAL RESOURCES

The Co-operative Housing Assistance Program (C.H.A.P.) Housing Program became, while it existed, a major educational tool in the acceptance of P.W.F. by providing information and training to home builder/owners on how to build P.W.F. as an alternate to concrete.

9. MANUFACTURING

Pressure treated wood is now being generally considered a "common" material useful for many types of construction and readily available from a number of locally based manufacturers and suppliers. It is therefore easy to get a P.W.F. if desired.

10. REGULATORY APPROVAL

Standards for P.W.F. are different in some provinces, and C.S.A. is working to establish consistent standard for P.W.F. across Canada. Since 1975 the Alberta Building Standards Branch has taken a more detailed regulatory approach to P.W.F. including the requirement that each foundation be engineered. This has had a mixed impact on the acceptance of P.W.F. While it provides a level of assurance to the home buyer that the foundation will perform properly, it also adds a cost to the house for the engineering services, a service which is not required for concrete foundation.

11. FINANCIAL/BUSINESS PLANNING:

Except for manufactures and suppliers little has been done. A number of P.W.F. specialist subtrade firms have evolved over the years but none has apparently been successful, reportedly because of poor business planning and misunderstanding of how P.W.F. could fit into the construction process. The cost of using specialist subtrade firms effectively prices P.W.F. out of the market in many areas, ultimately putting such firms out of business. Since most such P.W.F. firms were comprised of people who were originally doing framing and carpentry they went back to being framers when the P.W.F. specialist firms failed.

SUMMARY OF CURRENT STATUS

This innovation is in the marketing stage of development. Market penetration has been greatest where concrete costs are high. The distribution of P.W.F. is however uneven across the country with Alberta having the largest number in place and other parts having none. There is a slow but steady growth of P.W.F. in Alberta.

At this point in time P.W.F. must be considered a marginal success. Although it is a resonable product in terms of technical merit and cost, the fact that it does not offer significant advantages except under special circumstances provides little incentive to switch for the builder or buyer.

3. FACTORS AFFECTING TECHNOLOGY TRANSFER

.1 MARKET PERCEPTION OF THE FIELD OF FOUNDATION CONSTRUCTION AND HOW P.W.F. FITS IN THE PERCEPTION.

The typical house foundation for many years has been the concrete foundation which sets the standard by which other foundations systems are judged. The market however is interested in a foundation system that is less susceptible to interference from cold weather conditions during construction, doesn't crack or leak, and has better energy performance and improved comfort (not damp and cold). The market is also looking for an alternate to concrete in locations where the cost of providing concrete is high.

P.W.F. solves some of these problems. It reduces construction time and can be constructed more easily in cold weather. As a system, however, it is more sophisticated than concrete and does require a higher level of construction skill to erect. The cost of materials of a concrete foundation and a P.W.F. are about equal in urban areas, but in many rural areas the cost of concrete quickly exceeds the cost of preserved wood, giving P.W.F. a cost advantage.

A properly installed P.W.F. also results in fewer basement leaks, and the natural insulative properties of the wood result in a perceptibly less damp and cold space even without the addition of insulation and interior finish which is more easily applied to P.W.F. than a concrete foundation.

.2 INDUSTRY COMPONENTS INVOLVED

P.W.F. is a replacement technology. That is, the existing concrete residential foundation is completely replaced by P.W.F. from materials to labour. Thus since the growth of the P.W.F. market will be at the expense of the concrete foundation market, the diffusion of P.W.F. has two major sectors of the construction industry pitted against each other. These sectors consist of the wood industry, relevant trades, preserved wood manufacturers, building material suppliers and framing contractors on one hand, and the concrete industry including relevant trades, cement manufacturers, concrete suppliers and cribbers on the other hand.

The decision makers affecting the rate of diffusion of P.W.F. are the builder and, to a lesser extent, home owners, since the final choice of foundation is up to them.

.3 FACTORS AFFECTING THE DIFFUSION OF P.W.F.

The factors that are helping the diffusion of P.W.F. are:

.1 The high cost of concrete in some areas of the country.

.2 The advantage perceived by the house buyer in improved energy performance, appearance and comfort (relative advantage).

.3 Its ease of installation in bad weather (construction time).

The factors that hinder the diffusion of P.W.F. are:

.1 More sophisticated design and construction requiring a more skilled labour force (increased complexity, management risk).

.2 Not directly compatible with mainstream construction practice (compatibility, management risk).

.3 Sense of risk involved in long term structural stability and durability, (product risk, liability risk, reputation risk).

.4 Sense of risk in the potential long term exposure to toxic preservatives (information risk, liability risk, reputation risk).

.5 The builders perception that buyers don't like P.W.F. (competitive risk, reputation risk).

Most of the factors affecting diffusion affect the builder who has to weigh the pros and cons of using P.W.F. The most significant factor helping diffusion - cost - is less an attribute of P.W.F. than it is of concrete, which varies. Even when this factor is relevant to the builder, some of the benefit must be agreed upon by the house buyer for P.W.F. to be used. Of the remaining factors only the ease of installation in bad weather is directly useful to the builder. Arrayed against the positive factors are the full list of negative factors all of which are being actively highlighted by the concrete industry. The wood industry however does not appear to actively advertise the negative factors of a concrete foundation. In this situation the cost advantage of P.W.F. must be very high to balance the negative factors before the builder will switch.

4. POSSIBLE MEASURES THAT MIGHT HELP THE DIFFUSION OF P.W.F.

P.W.F. appears to be making inroads in areas where concrete costs are high. Where costs are more equal concrete is the preferred choice. The perception of the negative factors must be reduced before P.W.F. will make inroads in the urban areas where the costs of the two approaches are similar.

The long term goal might be to focus on the relative advantage of P.W.F. as perceived by home buyers. Most people who have a P.W.F. are happy with it and some actively promote it to their friends. A major area of new P.W.F. construction comes through referrals. The P.W.F. industry could profitably conduct surveys of this and promote the results. Even simple facts such as total numbers, growth rates, etc. would be valuable sign posts for consumers. A continued promotion of positive factors to consumers will help counteract the builders perception that buyers don't like P.W.F.

The factor of more sophisticated design and construction is a major organizational hurdle and ultimately a cost for builders. While it cannot be eliminated it can be turned into some advantage as described below.

.1 While it is possible to build a P.W.F. without engineering design and cost, doing so increases the risk of structural failure. This risk is substantially reduced by mandating the requirements for engineering as is done by the Alberta Building Code. Requiring engineers to design on P.W.F. has also provided a reservoir of professional skills which have continually improved and upgraded the system in ways to simplify the construction procedure, reduce costs and increase long term owner benefits.

.2 All other things being equal, an "engineered" product or system has appeal to many house buyers because it suggests a higher level of thought, skill and quality going into their home. However this is seen by most builders as a negative factor in that somehow the preserved wood is so poor or susceptible to failure that it needs "engineering" to bring it up to the standard of concrete.

> By proper advertising and promotion, the P.W.F. industry could turn this into an advantage in the eyes of the house buyer instead of a liability that even the industry believes. This advantage could also be expressed in terms of the professional liability protection owners and builders both get by having an engineer on the job.

While the construction of a P.W.F. is not simply a substitution of one sub-trade for another, the actual procedure for obtaining and installing a P.W.F. could be made easier for a contractor. When a contractor has to deviate from standard procedures he wants compensation for perceived risk of doing it wrong. An early approach, the formation of the P.W.F. specialist subtrade, has turned out to be too expensive to be an alternative. New procedures such as having the builder get the engineering done, buying the material and supervising his framer during the installation take time to learn and there is little incentive to spend the time if the cost of concrete is reasonable. A possible alternative which would simplify builder procedures is one where prefabrication and engineering are provided in one package (in fact one of the other innovations studied, the Nascor System, does exactly this). This approach has been accepted by builders in other areas of house framing including roof and floor trusses and stairs. This might be a new market area for the prefabricated housing industry.

At present the perception of risk of P.W.F. is so high with many builders that they will not use it even if P.W.F. is equal or lower priced than concrete. This could be countered if the builder knew more about buyer acceptability from sources they feel are unbiased. Therefore government participation could extend to funding a full comparison study of P.W.F. and concrete foundations including consumer satisfaction and ensuring the study's availability in the market place. Such a study could also investigate any long term toxic hazard of P.W.F.

CASE STUDY: RIGID FOAM INSULATION AND FRAMING SYSTEM (NASCOR SYSTEM)

INFORMATION SOURCE

The person interviewed specifically on the Nascor System was continously and directly involved with the innovation since its creation in 1982.

1. DESCRIPTION AND PRESENT STATUS OF THE RIGID FOAM INSULATION AND FRAMING SYSTEM (NASCOR SYSTEM)

The Nascor System consists of a unique structural column of 2 - 38 x 89 mm wood studs on the flat bonded to and separated from one another by a block of polystyrene "bead board". The columns are spaced by and connected to panels of "bead board" with polystyrene splines, and tied together at top and bottom by sawn lumber plates the thickness of the wall. The columns, panels and splines are manufactured and frequently preassembled off-site into walls in accordance with the specific requirements and layout of the building. With a slightly different configuration and using pressure treated wood the system can be also used for foundations. Using wood "I's" the system can be used for floor and roof structures. For purposes of this study it is classified as both a building product and a construction technique since the use of the system involves construction procedures unique to the product.

The primary source of the innovation is private research which started in 1982. Its place of origin is in Alberta but is based somewhat on similar systems and technology being developed elsewhere.

The original motivation appears to be the urge of the inventor to improve on the traditional methods of constructing a wall. The inventor thought that a manufactured modular system with no cavity in the wall, which builders could easily understand and install, would be readily accepted into the market and produce a substantial profit.

2. TRANSFER ACTIVITIES CARRIED OUT TO DATE ON NASCOR SYSTEM

The respondent thought the following activities have taken place in the implementation of the Nascor System:

.1 BASIC RESEARCH

The Nascor System does not involve basic research.

.2 APPLIED RESEARCH, PROTOTYPE CONSTRUCTION, PRODUCT ENHANCEMENT AND IMPROVEMENT

Applied research on the original concepts has been carried out by researchers at the University of Calgary, by private design and engineering consultants and by the Ontario Research Foundation.

A number of prototype houses were built in the "Riverbend" district in Calgary.

There is a continual program for product enhancement and testing. This program resulted in major improvements being introduced in 1984, and additional refinements are being considered although they remain confidential.

.3 FEASIBILITY STUDIES

Studies on the original concept were done by the innovator and his associates. Part of those studies involved reviewing other products and systems and how builders viewed and used them, and how the Nascor System could be designed to be readily usable.

.4 MARKET STUDIES, CONTINUED MARKET ANALYSIS AND MARKET PROMOTION

The first market studies were an integral part of the feasibility studies. Continued market analysis is ongoing but not extensive. Continued analysis of builder preferences are being made in order to find out how best to market the product. Currently, builder franchises are being considered. Market promotion is "Global" but not extensive. Plans are underway to expand market promotional efforts.

.5 FIELD MARKET TESTING

A number of builders have been supplied with product at reduced prices and assistance of the manufacturer to promote the system to builders and to show them how easy it is to use.

.6 UTILIZATION OF GOVERNMENT ASSISTANCE PROGRAMS

The manufacturer has sought and received assistance under the Innovative Housing Grants Program, Alberta Export Services and IRAP to carry out applied research work and international market evaluation. These grants are small in relation to the overall costs involved.

.7 EXTENSIVE USE OF PRIVATE CAPITAL

Most of the capital used so far is equity raised through private placement of shares or venture capital investment. Some of the investors have large capital resources.

.8 MANUFACTURING

To date all manufacturing has been by the system developer. However a joint venture is underway in Quebec, an American licence has been issued to a U.S. manufacturer, and the system may be manufactured in Europe under licence as well.

.9 REGULATORY APPROVALS

The system and product has full regulatory approval under Part 9 of the National Building Code.

.10 FINANCIAL/BUSINESS PLANNING

It is considerable at this time, particularly in order to complete private placements of company shares. There is continued effort to get new investors or to try spread the risk through joint ventures, licences, franchises.

SUMMARY OF CURRENT STATUS

This innovation is in the marketing stage, and efforts are being focused mainly in Western Canada and Ontario. To date over 6000 housing units utilizing the system have been built and the numbers are growing. At the same time other systems and products with similar characteristics are appearing on the market. These factors suggest that the Nascor System is probably a successful innovation.

3. FACTORS AFFECTING TECHNOLOGY TRANSFER

.1 MARKET PERCEPTION IN THE FIELD OF HOUSING ENCLOSURE AND STRUCTURAL SYSTEMS AND HOW THE NASCOR SYSTEM FITS THAT PERCEPTION

Few people expect to see in the next few years major or fundamental changes in the way houses are built. This is not to say that builders would not like to see a house built more quickly with cheaper labour and at lower overall cost, nor that owners do not want a more energy efficient and comfortable home. It is just that the present system of construction does not seem to them open to significant improvements.

The Nascor System is intended by the innovator to introduce major changes to how a house is built. Through partial prefabrication labour costs are reduced as is site construction time. Material costs are not reduced since high quality wood is used and polystyrene insulation is more expensive than most batt insulation. The system gives good energy performance and, because it is relatively air tight, improves comfort levels. It is likely more durable since there are no voids in the wall to collect condensate and rot the wood.

.2 INDUSTRY COMPONENTS INVOLVED

The Nascor System is a replacement technology. It can replace most of the labour and material involved in constructing the structural frame and room enclosure as well as the insulation. Under appropriate application it can also eliminate the polyethylene. Its main proponent is the manufacturer who is also supported by the polystyrene foam industry. Small informal surveys to date indicate generally a favourable response to the system by house buyers, but relatively little interest by any other component in the industry.

As the Nascor System becomes more widely known, however, it would appear that the concrete trade, the polyethylene industry and building material suppliers could be quite negative. The other components will not be affected much. The framer will install the package on site. The system has been designed to accommodate the needs of the electrical and mechanical trades, and it utilizes almost the same amount of wood as does conventional framing. It is the builder however who makes the final choice.

.3 FACTORS AFFECTING THE DIFFUSION OF THE NASCOR SYSTEM

The factors that are helping the diffusion of the Nascor System are:

.1 The apparent ease of installation and simplification of construction procedures due to the degree of prefabrication (relative advantage, reduced complexity to builder).

.2 Increased heat and sound insulation, and air/vapour properties producing improved energy performance and comfort (relative advantage to owner).

.3 Better backing for finish materials and better dimensional accuracy of walls and floors ultimately allowing the use of less wood (reduced material cost, improved appearance).

The factors that will hinder diffusion of the Nascor System are:

.1 The perceived risk that the system has not been sufficiently tested for a long enough period (product risk, information risk).

.2 The system is a change from conventional building practice (reduced compatibility, strategic risk, management risk).

.3 The market perception that the present materials and methods are generally adequate (market risk).

The pro and con factors affecting diffusion focus on the manufacturer, builder and owner. In developing the system the manufacturer has tried to go as far as possible to cater to the builder by making the system cost effective, by ensuring most conventional materials can be used with it and by making sure that it is as compatible as possible with existing subtrades. It appears that the builder is saving money using the system but as yet feels that the saving is barely adequate to compensate him for the risk he takes in changing systems. Consequently none of the savings are being passed on to house buyers.

House buyers are being sold on the energy efficiency and other properties that would make the house more comfortable. Since most buyers expect these properties to cost more, those that want them are prepared to pay more for the Nascor System. This group of buyers however is not large as yet, which limits the diffusion rate of the system. This is frustrating since the manufacturer believes the installed system is actually more economical than standard practice.

4. POSSIBLE MEASURES THAT MIGHT HELP THE DIFFUSION OF THE NASCOR SYSTEM

While the Nascor System was originally modified to make it easier for the ordinary house builder to use, the system appears to have a number of potentials yet to be exploited once the system becomes better known. The first is the potential for reducing the amount of wood to that required for structural support. Convential framing uses more wood than is structurally necessary in order to support the finish material. The Nascor System with the foam plastic support of the finish material offers the opportunity of reducing the amount of wood required by a significant percentage.

The second potential that is likely to be exploited is the ease by which the system can be incorporated into a house manufacturing system. The modular home industry at present utilizes and is limited by its adoption of most of the standard construction techniques. The Nascor System allows the industry to start from a different position utilizing a system which is inherently more adapted to the manufacturing process. In this respect licences have been issued to the first of a number of prefabrication firms interested in the system.

Although it is not yet a high priority with the innovator, the reduction of the amount of wood in a wood frame house will need the help of government. Technical studies are required to confirm structural strengths and to outline the methods of assembly that would allow the building code to be revised to allow the use of less wood. At present the building code does not allow the reduction except in a fully engineered design, which is costly.

CASE STUDY: DRYWALL CLIPS

INFORMATION SOURCE

It was not possible to interview anyone directly involved with drywall clips. In fact all contacts were considered remote. The comments below are the result of discussion with these remote contacts plus written articles on the innovation.

1. DESCRIPTION AND PRESENT STATUS OF DRYWALL CLIPS

Drywall clips are "U" shaped sheet steel devices approximately 40 mm long with a tongue projecting from the bottom of the "U" added to enable nailing to a framing member. The clips are attached approximately 400 mm apart onto the edge of a sheet of drywall before it is installed and nailed to the framing member when the drywall sheet is put into place. This eliminates the use of wood backing behind the edges of the drywall when there is a wood corner or edge to butt into. For the purposes of this study it has been classified as a building product.

Apparently the primary source of the innovation is an inventor in the United States, who was trying to improve on existing clip designs which were not popular because they needed to be attached to the wood first, and thus were easily misaligned. In the late 1970's he was able to obtain a patent.

The motivation appears to be perceived opportunity by the innovator to reduce the cost of housing construction with a simply made device, and that once this was understood by builders they would buy millions of them.

2. TRANSFER ACTIVITIES CARRIED OUT TO DATE ON DRYWALL CLIPS

The respondents knew little of the activities involved in implementing drywall clips and the articles checked did not discuss the issue.

The present status of the innovation is in the marketing stage and it appears to be making significant inroads into the U.S. market. There is, however, little or no market for drywall clips in Alberta.

3. FACTORS AFFECTING TECHNOLOGY TRANSFER

.1 MARKET PERCEPTION IN THE FIELD OF INSTALLING DRYWALL AND HOW THE DRYWALL CLIP FITS THAT PERCEPTION

The installation of drywall requires that the edges of the panel be supported. While the typical procedure involves installing extra studs at the corners and wood blocking elsewhere, most builders appreciate that this takes extra material and is one of the areas which requires supervision, since framers tend to leave some of it out.

The drywall clip is an improvement on the traditional procedure in that it eliminates studs and blocking amounting to approximately 10% of the total amount of wood used. It also reduces framing labour time. It does require the drywall contractor to purchase and install the clips.

It improves appearance and life cycle costs because it produces a much straighter corner, reduces the chances of drywall cracks in the corners, and increases energy performance by allowing more insulation in the exterior walls at corners and wall intersections.

.2 INDUSTRY COMPONENTS INVOLVED

Drywall clips are intended to substitute the conventional materials and procedure for supporting drywall edges by one that utilizes a patented device. Its main proponent is likely the inventor, and the material suppliers marketing the product. In Alberta there is little knowledge or interest in the product by any component of the building industry. However should it become known it would appear that builders will likely be supporters as will the drywall contractors and their suppliers. Eventually house buyers may become advocates if it can be shown that the quality of the installation is improved and drywall cracks are actually reduced.

.3 FACTORS AFFECTING THE DIFFUSION OF DRYWALL CLIPS

The factors that should be helping the diffusion of drywall clips are:

.1 The clips are easy to install requiring no extra skills (compatibility, reduced complexity, trialability, to drywall contractor).

.2 There is a saving in the cost of wood and the installation of blocking (relative advantage to builder and owner).

.3 There is improved appearance with straight corners, fewer cracks, and better energy performance (relative advantage to owner).

The factors that are hindering the diffusion of drywall clips are:

.1 Lack of information on drywall clips (information risk).

.2 The extra cost for the supply and installation of drywall clips (relative disadvantage to drywall contractor).

.3 The need for the builder to co-ordinate the framing trade and the drywall trade so that he can get sufficient framing labour savings to offset the extra drywall costs (management risk).

The pro and con factors affecting diffusion focus on the builder, but at present it appears that in Alberta the questions of diffusion are academic because builders are unaware of the product. Building material suppliers to the drywall industry are somewhat aware of it and a couple have a small stock and very little amount of literature. The brochure that is available from the U.S. manufacturer contains the names and phone numbers of a firm in Canada which has since gone out of business, and phone calls to the U.S. phone number in the brochure are to an answering service. Therefore the suppliers do not promote it and there have only been minor sales in the last few months in Edmonton.

4. POSSIBLE MEASURES THAT MIGHT HELP THE DIFFUSION OF DRYWALL CLIPS

It appears that drywall clips are a useful cost effective innovation that would likely be used if builders and drywallers knew about them. The lack of information in Alberta may be due to the lack of interest by the inventor in setting up a proper distribution system in Canada possibly because he is doing so well in the United States. Unless someone locally is interested enough to provide local promotion the diffusion of the product is likely to be delayed significantly.

Normally this would be a matter for private industry to sort out but it would appear that drywall clips could make a significant contribution by reducing joint cracking particularly as it relates to truss uplift. Possibly through testing drywall clips to reduce such problems the government could gain the interest of those builders or building material suppliers who might be prepared to take on local promotion of drywall clips in the market place.

CASE STUDY: AIR TIGHT DRYWALL APPROACH (A.D.A.)

INFORMATION SOURCE

The persons interviewed specifically on A.D.A. are directly involved in both building science and residential construction. They first became aware of A.D.A. in 1983 at one of the many lectures of J. Lstiburek, the pioneer of the concept, and have installed A.D.A. in a number of houses.

1. DESCRIPTION AND PRESENT STATUS OF AIR TIGHT DRYWALL APPROACH TO VAPOUR/AIR BARRIER

A.D.A. is a constructional approach whereby the traditional polyethylene film vapour barrier is abandoned in favour of making the gypsum wallboard surface along with the use of foam gasketing the air barrier, and a painted finish with a low perm rating as the vapour diffusion retarder. For purposes of this study it is classified as a construction technique since it does not involve a major use of new materials but is more a revision to the way the typical materials are installed.

The major impetus for this innovation seems to be the work of J. Lstiburek who constructed and tested a number of houses in Ontario in 1982 and 1983. These were based on an earlier effort at producing air tightness in the Mark 7 House built in 1971 by The Canadian House Builders Association. The funding for this work was by C.M.H.C. as part of a moisture research and monitoring project. Further refinement of the A.D.A. concept was demonstrated in houses constructed in Alberta in 1984 supported by funding from the Alberta Department of Housing.

The original motivation for A.D.A. is thought to derive from the levels of dissatisfaction some builders were having in installing polyethylene sheet properly. It was clear that houses built to conventional standards and including a polyethylene vapour barrier were not very energy conservative because of air leaks, and efforts to reduce the leakage by trying to install the polyethyene more carefully were shown to be labour intensive in relation to the quality of the result.

2. TRANSFER ACTIVITIES CARRIED OUT TO DATE ON A.D.A.

The respondents thought the following activities have taken place in the implementation of A.D.A.

.1 BASIC RESEARCH

A.D.A. generally does not involve basic research although there has been research on the degradation of polyethylene film.

.2 APPLIED RESEARCH, PROTOTYPE CONSTRUCTION, PRODUCT ENHANCEMENT AND IMPROVEMENT

A number of test houses have been built since 1971, each group being based on improvements identified in the construction and monitoring of the earlier group. This work has been carried out by contractors working in concert with building scientists and engineers. At present applied research is being conducted on establishing various standards to determine the adequacy of paints as effective vapour retarders.

.3 FEASIBILITY STUDIES

Studies accompanying the test/demonstration projects have examined feasibility of A.D.A. in terms of technical/mechanical difficulties, acceptance by trades and building cost implications.

.4 MARKET STUDIES, CONTINUED MARKET ANALYSIS AND MARKET PROMOTION

No market studies are known to have been done. Market analysis and promotion is done in a minor way by the firms that use it in their energy upgrades by noting the reactions of their customers.

.5 FIELD MARKET TESTING

A few builders are providing houses with A.D.A. as part of their energy upgrade package directed towards R-2000 performance criteria. However because A.D.A. is not approved under the code they are still including polyethylene sheeting in the construction.

.6 UTILIZATION OF GOVERNMENT ASSISTANCE PROGRAMS

Most of the applied research and feasibility studies to date have been assisted by grants from C.M.H.C. and the Alberta Innovative Housing Grants Program.

.7 USE OF GOVERNMENT NON-CAPITAL RESOURCES

The Housing Research and Development Section of Alberta Municipal Affairs has assisted A.D.A. development by supporting and advising on a number of studies and test projects.

.8 EXTENSIVE USE OF PRIVATE CAPITAL

The innovation is not capital intensive. However A.D.A. does require special gasketing and caulking and American companies have geared up quickly to supply the demand.

.9 MANUFACTURING

See Item 8 above.

.10 REGULATORY APPROVAL

A.D.A. is being reviewed by Alberta Standards Branch, which administers the Alberta Building Code. It however does not have approval except where a design professional takes responsibility of the design and construction. The key difficulty is getting approval of certain types of paint as accepted vapour retarders.

.11 FINANCIAL/BUSINESS PLANNING

A.D.A. has had little impact, nor is it affected by the financial or business planning of the firms attempting to employ it.

SUMMARY OF CURRENT STATUS

The present status of the innovation is the field demonstation stage with a number of builders constructing houses using A.D.A. as part of an energy conservation construction approach and evolving new details over time.

A.D.A. does not have formal regulatory approval because the use of paint has not been approved as a vapour retarder. Presently the research and development section of the Housing Division of Municipal Affairs is sponsoring research to help establish paint as an effective vapour retarder. It is premature to consider it a success although with regulatory approval success is likely.

3. FACTORS AFFECTING TECHNOLOGY TRANSFER

.1 MARKET PERCEPTION IN THE FIELD OF VAPOUR/AIR BARRIERS AND HOW A.D.A. FITS IN THAT PERCEPTION

The purposes and requirements for air and vapour diffusion retarders is not widely understood in detail although there is increasing awareness among both builders and house buyers as to their importance. From a builder's point of view the polyethylene vapour barrier has always been difficult to install and takes a more skilled labourer more time to install than it used to in order to meet today's standards. More builders now know that even with the extra effort, the long term result may still not be effective since the polyethylene has been known to rip in the walls due to differential air pressures thus reducing energy performance and comfort.

A.D.A. addresses number of these concerns and provides additional advantages. It results in an energy efficient air tight house and reduces construction and labour time through the elimination of the polyethylene vapour barrier although these are not considered significant savings reflected in the total cost of the house. A.D.A. requires less skill to install than properly installed polyethylene, the difficulty of which is just becoming apparent to many builders. The life cycle cost of A.D.A is also likely less than conventional techniques since A.D.A. is easy to check and repair thus retaining the air barrier necessary for improved energy performance and comfort.

.2 INDUSTRY COMPONENTS INVOLVED

A.D.A. is a technology which eliminates the use of the polyethylene air/vapour barrier. It uses gypsum wallboard finish and gasketting as an air barrier and paint as a vapour retarder. Its main proponents seem to be builders and building technologists who see it as part of a larger scheme to produce an energy efficient house at minimal additional cost. It is also increasingly supported by architects, some who are using it in commercial construction. It has no dramatic impact on trades since all the work of installing the polyethylene and most of A.D.A. come under the drywall trade with some of the caulking and gasketing done by the framer. The increased use of A.D.A. may, however, affect the polyethylene film industry which has the capacity to actively campaign against its adoption. Also the regulatory agencies have yet to rule on the acceptability of A.D.A. in the building code, which affects at present the attitude of the financial and insurance components.

.3 FACTORS AFFECTING THE DIFFUSION OF A.D.A.

The factors that will help the diffusion of A.D.A. are:

.1 The ease with which it can be installed (compatibility, trialability, reduced complexity).

.2 The reduced construction costs involved.

.3 Market perception that polyethylene is not the way to go (market risk).

The factors that will hinder the diffusion of A.D.A.

.1 Lack of code approval (information risk, product risk).

.2 The apparent risk of sealing the house so tight that there is not proper ventilation without an advanced ventilation heating system (strategic risk, reputation risk).

.3 The apparent risk that sufficiently high air tightness will result in deterioration of the house in unexpected ways (product risk, information risk).

The pro and con factors affecting diffusion focus on the builder and the regulator. The innovation has the potential to be quickly adopted once it obtains regulatory approval primarily because the drywall trade will find it easier to install with little impact on practice of other subtrades or the builder. The drywall trade will receive financial benefit as well. Its adoption will be seen as beneficial because it achieves the public objective of air tightness and energy efficiency with reduced effort and cost.

Its major liability in the long run is that it may be too good. Drywallers may be making houses too airtight before builders and heating contractors have learned how to solve the humidity and fresh air problems that result. It would appear that in considering approving paint as a vapour retarder, thus finally allowing the elimination of polyethylene sheet, regulators should note that A.D.A. includes an adequate ventilation system for fresh air and humidity control.

CASE STUDY: PREFABRICATED WOOD "I" (P.W.I.) STRUCTURAL BEAMS

INFORMATION SOURCE

The persons interviewed specifically on P.W.I. are directly involved in the development and manufacturing of the innovation and for specifying on its proper use in construction. They have been involved with P.W.I. since or close to its introduction in Canada in 1983.

1. DESCRIPTION AND PRESENT STATUS OF PREFABRICATED WOOD "I'S"

P.W.I. is a manufactured wood truss consisting of 38 x 89 mm wood flanges connected to an oriented strand board (O.S.B.) web with a patented wood joint. For purposes of this study it is classified as a building product.

The primary source of the innovation is an American inventor who patented the joint in the late 1970's but who was not successful in commercially exploiting the idea. The patent was purchased and brought to Canada in 1983 and further developed using Alberta materials.

The original motivation to bring the patent to Canada was through a Canadian purchaser who already had a truss plant in operation and was looking for product that would allow the plant to manufacture to inventory instead of custom requirements. The plant could then be run efficiently at a steady state independently of fluctuating sales. The P.W.I. fitted this requirement. Since then the manufacturer has been marketing the product heavily to the commercial and residential construction industry.

2. TRANSFER ACTIVITIES CARRIED OUT TO DATE ON P.W.I.

The repondents thought the following activities have taken place in the implementation of P.W.I.

.1 BASIC RESEARCH

P.W.I. does not involve basic research.

.2 APPLIED RESEARCH, PROTOTYPE CONSTRUCTION, PRODUCT ENHANCEMENT AND IMPROVEMENT

After the patent was purchased, much development work was done on testing materials, glues, jointing, structural failure testing, manufacturing jigs, plant layout, etc. Much of the work was of the "hands on" non-academic type done under the direction of staff engineers. There is a large amount of continuing developmental work to refine the manufacturing process, both in equipment and assembly and testing of components.

.3 FEASIBILITY STUDIES

Before patent purchase a feasibility study was done on technical aspects of concept and how it might economically be manufactured with respect to other truss products.

.4 MARKET STUDIES, CONTINUED MARKET ANALYSIS AND MARKET PROMOTION

No formal market studies have been done and the present understanding of the market is intuitive and based on experience. There has however been a lot of market promotion related to the size of the manufacturer and product is quite well known and accepted in the building industry. The manufacturer has been able to cash in on the market promotion of a similar looking product by a competing manufacturer which is more expensive.

.5 FIELD MARKET TESTING

A considerable amount of field market testing has been done, including providing builders with product at or below cost to get them to use it.

.6 UTILIZATION OF GOVERNMENT GRANT PROGRAMS

Available grants have been utilized from the Innovative Housing Grants Program, I.R.A.P. and Forestry. The amount was small in relation to total expenditure.

.7 USE OF GOVERNMENT NON-CAPITAL RESOURCES

Minor use has been made of some of the government work programs.

.8 EXTENSIVE USE OF PRIVATE CAPITAL

Millions of dollars have been expended to date.

.9 MANUFACTURING

All manufacturing to date has been done by the manufacturer which is building additional plants to satisfy demand, rather than licence the product to others.

.10 REGULATORY APPROVALS

The product is accepted by all appropriate regulatory authorities in Canada and U.S. although initial approval for residential construction was difficult.

.11 FINANCIAL/BUSINESS PLANNING

The manufacturer's organization had been in business successfully for many years before the purchase of the patent, and the purchase of the patent and decision to develop and manufacture P.W.I. was part of a long term business strategy.

SUMMARY OF CURRENT STATUS

The product is in the marketing stage with product being sold across the country. Market penetration is growing, and the innovation should be considered a success since other manufacturers are introducing similar products.

3. FACTORS AFFECTING TECHNOLOGY TRANSFER

.1 MARKET PERCEPTION OF THE FIELD OF JOIST SYSTEMS AND HOW P.W.I. FITS THAT PERCEPTION

In typical residential construction, joists are dimensioned construction grade or better lumber. On a piece-by-piece basis the quality is highly variable, with warpage and knots being a constant problem. Dimensional lumber joists also have limited spans. While these attributes reduce the quality of construction and can lead to call backs and excessive maintenance, most builders feel this is just part of the nature of residential construction. Even the relatively short allowable spans are generally acceptable in present house plans.

P.W.I.'s address most of the drawbacks of the typical joist of sawn lumber even though most builders are not seriously concerned. They reduce construction and labour time since they do not have to be site graded and located because each joist has the same properties as any other. They also arrive on site at the proper length so there is reduced cutting. P.W.I.'s are available in long spans which allow more freedom in interior planning and flatter floor construction. They also have a more positive image than standard lumber because of their technological precision.

The most unfortunate property of P.W.I.'s is that they cost more than standard lumber, although with proper planning in the initial design stages of a house, the difference can be reduced. Also, the trades that typically cut holes in the structural frame to fit their work in have to be more careful where they cut.

.2 INDUSTRY COMPONENTS INVOLVED

While P.W.I. replaces cut lumber the source of material for P.W.I. is from the same industrial sector, the forest industry. Additionally, the installation of standard wood joists and P.W.I. is by the same trade. The primary relationship seems to be a building product manufacturer trying to market his product to the builder. In this he is supported by engineers and architects who design and specify the product. On the other hand the residential mechanical and electrical trades have some misgivings because they have to be more careful in cutting P.W.I. to fit their systems in.

Full regulatory approval has been obtained for P.W.I. and all other components of the industry play a peripheral role in its diffusion.

.3 FACTORS AFFECTING THE DIFFUSION OF P.W.I.

The factors that are helping the diffusion of P.W.I. are:

.1 The ease with which it can be installed (compatibility, triaiability, communicability).

.2 It can span large spaces and produce flatter floors (relative advantage).

The factors that hinder the diffusion of P.W.I. are:

.1 The risk that the buyer will not pay the higner price of P.W.I. (competative risk).

.2 Market perception that present materials and methods are generally adequate (market risk).

The pro and con factors affecting diffusion focus on the manufacturer and the builder. The manufacturer has recognized that most houses don't have sufficiently large spaces that require long span joists. Those that do are usually the larger higher priced house which can afford the extra cost. This is exactly how the product is being used by most builders. While some tried for a short while to make P.W.I. a standard in their higher priced houses, they have reverted to using it only when the spans require it.

4. POSSIBLE MEASURES THAT MIGHT HELP THE DIFFUSION OF P.W.I.

The manufacturer recognizes that the main market for P.W.I. is likely to be in commercial and apartment construction and only peripherally in single family residential construction. Unfortunately in this market one of the factors affecting the rate of diffusion is the code provisions relating to fire separation and combustibility which limits the size and type of building that P.W.I.'s can be applied to although they would be functionally appropriate and a cost effective alternative. These provisions do not apply to the single family housing market.

There appears to be no need for further governmental involvement in this product as far as residential construction is involved unless the work pertains directly to bringing the cost down. Since the manufacturer is also in the commercial market which generally wants longer spans where P.W.I. is cost competitive, there is at present no real incentive for him to try to reduce costs.

CASE STUDY: PREFABRICATED STRESSED SKIN FOAM CORE PANEL (SEVEN-S SYSTEM)

INFORMATION SOURCE

The person interviewed from Seven-S has been directly involved in the development and production of this innovation since 1985 when it was decided that a pilot plant was required for prototype testing.

1. DESCRIPTION AND PRESENT STATUS OF THE SEVEN-S SYSTEM

The Seven-S System is a stressed skin panel system consisting of surfaces of oriented strand board (OSB) enclosing a core of injected urethane foam and OSB stiffeners. The panels can be used for walls, floors and roofs. For the purpose of this study it is classified as both a building product and a construction technique since the use of the panels involves construction procedures unique to the product.

The primary source of the innovation was work done by a building contractor in Alberta starting in 1982. The original motivation for the system came from the builder's own dissatisfaction with the present method of building houses. While this is not a widespread concern of most builders, the innovator of the system believes the market can be pushed to buying it once it understands the system benefits.

2. TRANSFER ACTIVITIES CARRIED OUT TO DATE ON SEVEN-S SYSTEM

The respondent thought the following activities have taken place in the implementation of the Seven-S System.

.1 BASIC RESEARCH

The Seven-S System does not involve basic research.

.2 APPLIED RESEARCH, PROTOTYPE CONSTRUCTION, PRODUCT ENHANCEMENT AND IMPROVEMENT

A great deal of "garage lab" work was done, with different skin materials, foams, structural stiffners etc. until the concept was sufficiently developed so a patent could be applied for. Much of the work was of the "hands-on" non-academic type done by semi-skilled workers. A pilot plant has also been constructed to develop manufacturing procedures. Product from the plant has been used in the erection of farm and industrial buildings as well as a small number of houses. At present there are no test or evaluation reports available.

.3 FEASIBILITY STUDIES

None have been done to date.

.4 MARKET STUDIES, CONTINUED MARKET ANALYSIS AND MARKET PROMOTION

No market studies have been done to date. A small amount of promotion has been done with the preparation of a brochure and a video.

.5 FIELD MARKET TESTING

Field market testing is about to begin with the construction of model houses in foreign markets.

.6 UTILIZATION OF GOVERNMENT ASSISTANCE PROGRAMS

The manufacturer is attempting to obtain large grants to help underwrite developmental expenses. So far it has received small grants for testing and quality control.

.7 USE OF GOVERNMENT NON-CAPITAL RESOURCES

The Department of Economic Development has helped in making foreign market contacts. The Research and Developmental Section of Municipal Affairs has also helped in a number of ways. However, the impression of Government help so far is that it is small, compared to what is needed.

.8 EXTENSIVE USE OF PRIVATE CAPITAL

Almost 1 million dollars has been spent to date. A program is underway to raise additional private capital on the stock market.

.10 MANUFACTURING

To date, all manufacturing has been in the manufacturer's pilot plant.

.11 REGULATORY APPROVALS

The system has been evaluated by C.M.H.C. and Alberta Building Standards Branch. Regulatory approval will be subject to limitations not all of which have been clearly defined, particularly regarding structural considerations.

.13 FINANCIAL/BUSINESS PLANNING

A financial/business plan has been prepared in house and is ready for implementation. There is considerable effort being carried out to raise funds in the Alberta capital market (see Item 9).

SUMMARY OF CURRENT STATUS

This innovation is in the field demonstration stage with a number of test buildings being erected in Alberta. The system is being marketed to foreign buyers who will shortly be evaluating demonstration houses in their country. It does not as yet have full regulatory approval or clearly defined regulatory limits, although the Building Standards Branch is monitoring the situation.

It is premature at this time to consider the system a success or failure. Three other innovators are apparently working on similar systems in the U.S.

3. FACTORS AFFECTING TECHNOLOGY TRANSFER

.1 MARKET PERCEPTION IN THE FIELD OF HOUSING ENCLOSURE AND STRUCTURAL SYSTEMS AND HOW THE SEVEN-S SYSTEM FITS INTO THAT PERCEPTION

In a very general sense most people would like to see the cost of housing reduced, and the quality improved, but few expect to see it accomplished in any dramatic way. There is not a strong feeling that the time engaged in building the structure and walls of a house is too long, that there is too much highly skilled labour time being used, that materials costs are too high or that the structural shell is not durable enough. There is however a desire for improved energy performance and comfort although not at large cost.

The Seven-S System is intended to improve the construction of the structure walls of a house by utilizing a completely different approach to the traditional on-site construction. By prefabricating the panels in a plant, the average labour skills, although different, are reduced, productivity is increased due to reduced impact of weather, and labour costs are reduced. While material costs are not reduced, the on-site construction time is decreased.

The system with its urethane foam core gives good energy performance and improves comfort.

.2 INDUSTRY COMPONENTS INVOLVED

The Seven-S System is a replacement technology. It replaces all the labour and material involved in constructing the structural frame and room enclosure as well as the insulation and vapour/air barrier. Its main proponent is the product manufacturer. Arrayed against him are the concrete trade (the system can replace concrete foundations), the framers, the electrical and plumbing trade, the forestry industry and building material suppliers. Standing in the middle is the builder who must decide which way to go. All other components of the industry will play a peripheral role once a complete regulatory definition has been made.

.3 FACTORS AFFECTING THE DIFFUSION OF THE SEVEN-S SYSTEM

The factors that could help the diffusion of the Seven-S System are:

.1 The apparent ease of installation and simplification of construction procedure (relative advantage, reduced complexity to builder).

.2 The increased dimensional accuracy of walls and levelness of floors, improved energy performance and comfort (relative advantage to owner)

The factors that will hinder diffusion of the Seven-S System are:

.1 Regulatory restrictions which will serve to increase costs (product risk, information risk).

.2 The risk that the product has not been sufficiently tested for a long enough period (product risk, competitive risk, information risk).

.3 The extensive departure of this approach from conventional building practice (low compatibility, strategic risk, management risk).

.4 The risk that the manufacturer may not be in business long enough to give full warrentee support if required (financial risk, reputation risk, liability risk).

.5 The market perception that present materials and methods are generally adequate (market risk).

The pro and con factors affecting diffusion focus on the manufacturer and the builder. There is currently little knowledge of the system in the building industry and consequently little diffusion. However as the system becomes more well known it is clear that the builder will be influenced by the opinions of the industry components which will be directly affected. They may focus on the issue of non compatibility with present methods and how difficult it is to change. The heightened sense of risk will have cost consequences and unless the Seven-S System is substantially less costly than the conventional system the builder likely will not switch. The manufacturer's major problem will be staying in business throughout the diffusion process. He is a new player, without a great depth of financial resources and this will affect the builder's opinion of his credibility which in turn will act to slow down the rate of diffusion.

4. POSSIBLE MEASURES THAT MIGHT HELP THE DIFFUSION OF THE SEVEN-S SYSTEM

The manufacturer seems to implicitly understand the possibility of slow diffusion in the local market and so is trying to break into foreign markets in a major way. With a potential off-shore sale of 2,000 housing units presently being negotiated, this kind of market development could support the construction of a full manufacturing facility as well as work bugs out of the innovation. Because the innovation is still effectively unproven, however, and there are inherent risks in selling to a naive purchaser the financing needed to begin large scale manufacture will likely be difficult to acquire because of risk of failure.

The innovator is therefore very interested in additional government support. It would appear however that the innovator is premature in asking the government to underwrite risk. At least two major studies should probably be completed prior to the request: a market study and a feasibility study. The market study will identify market preferences for such a system and the feasibility study will outline how the system can be modified, if necessary, to accommodate these preferences. The feasibility and market study are particularly important in going into unfamiliar foreign markets to ensure that proper "cultural etiquette" and sensitivities are addressed. Technical studies (as part of the feasibility study) are needed to reduce the possibility of failure due to unknown environmental impacts (say for example termite attack on O.S.B.).

These types of studies which can be partially funded by government grants would go a long way to elevating private sector investor uncertainty and would help to focus the innovator on the shape of the market and how to break into it effectively.

APPENDIX D

BUILDER PERCEPTION AND USE OF INNOVATIONS IN RESIDENTIAL CONSTRUCTION

INTRODUCTION

A cross-section of 13 Alberta Builders was interviewed regarding their perception and use of the eight innovations examined in this study. The interviews were guided by the Interview Guide shown in Appendix B. These builders have been responsible for the construction of approximately 900 houses per year over the past 5 years and build from 4 houses per year to 200 houses per year. This represents the full range of firm sizes in the Albera housing market today. Six of the builders were located in Edmonton, five in Calgary and two in Lethbridge.

The majority of the builders interviewed have been involved in residential construction for 10 to 15 years with only a very small number (2) with 20 or more year's experience. All the builders had technical school education or better, with the majority (67%) having a university education. Very little of this higher education including virtually all the university education was directly applicable to residential construction. In fact, approximately two-thirds of those interviewed have taken no specific courses on residential construction, learning everything they know on the job. The bulk of the specific courses taken relate to technical school or to the R-2000 training program.

Readers should remember that the interview results summarized below are derived from a relatively small number of interviews. This limits their comprehensiveness and generalizability.

INTERVIEW RESULTS

1. ORIENTED STANDARD BOARD (O.S.B.)

Most of the builders (75%) have used O.S.B. with approximately 40% using it extensively. Approximately 85% of the builders would accept a home purchaser recommendation for its use. However, a majority (60%) would not allow a trade to make the choice. The builder perception of its present market acceptability ranged from low and medium.

The builders had a clear and consistent understanding of how O.S.B. contributes to the construction process (question 15). Virtually all (95%) believed it has no effect on construction time, labour time, labour skills, life cycle costs, energy performance, safety (except for slippage on roof), comfort level, or durability. They (100%) believed its major contribution was in cost savings (including first costs savings to owners) and that its major detraction was appearance since it looked like cheap waferboard, which they say house buyers don't like.

Builders were also very clear on their perceptions of the potential benefits of O.S.B. to themselves (question 16). The majority (70%) of those that have used O.S.B. saw it as having a relative advantage of cost, being compatible with their construction methods and easy to try. The builders (60%) had a little more difficulty with communicating to the house buyer the differences between O.S.B. and waferboard.

Regarding the question of risk, some builders (40%) were concerned with product performance (product risk). The majority of builders however generally saw no risk in using O.S.B. except the risk of buyer rejection (competitive risk) and the affect its use may have on their reputation. In these two areas of risk there was no consensus.

The interview results indicate a conflict in perception. Most of the builders have a very negative view of O.S.B. which they attribute to the perception of the buyers. However most were somewhat surprised to learn that they had shown O.S.B. to confer benefits with little technical risk to the builder in all categories, after previously making derogatory comments. The problem appears to be that many builders do not clearly understand the difference between O.S.B. and waferboard, and some of those that do are still skeptical that O.S.B. is structurally as good as plywood.

2. MEDIUM DENSITY FIBERBOARD (M.D.F.)

Approximately 75% of the builders have used M.D.F. with approximately 30% using it extensively. While 65% would accept a home purchaser's recommendation on its use only 50% would allow subtrades to use it on their suggestion. There is no consensus among builders as to its present market acceptance, with some thinking it high and an equal number thinking it low.

Builders have a fairly clear understanding of how M.D.F. contributes to the construction process (question 15). While most (75%) who are familiar with the material feel it has no effect on construction time, labour time, labour skills, life cycle costs, energy performance, safety or comfort, some (25%) think it does decrease construction and labour time. The majority (75%) however felt it is less costly than competing products, particularly plywood, thus decreasing first costs. It also produces a better looking product, particularly along the cut edges. There is less consensus on its durability with approximately half saying it is more durable and the other half saying it is not.

Builders were clear and consistent on the benefits of M.D.F. to themselves (question 16). Almost 100% of those who have used it rated it highly for compatibility, ease of use and cost advantage. It seems to have no drawbacks as far as risk is concerned with almost 100% of those who have used it seeing no risk in using it. There was only a small concern (20%) that the product will not perform as expected (product risk).

The interview results indicate that M.D.F. is having good builder acceptance. All of the builders who have used it liked it although they are not using it as much as they could because they have not considered all its possible uses. For those who have not used M.D.F. the problem seems to be simply one of lack of information. They know little or nothing about it.

3. PRESERVED WOOD FOUNDATION (P.W.F.)

Approximately 65% of the builders interviewed have installed P.W.F. and an equal percentage would accept a home purchaser's recommendation on installing a P.W.F. but would not allow the subtrades the option. Interestingly, although a significant number have installed a P.W.F., they think present market acceptance is low which is also indicated by the fact that only a couple of builders have built a significant number.

On the question of P.W.F.'s contribution to the construction process (question 15) the builders were clear in some areas and not in others. The majority (85%) believed there is no change in material costs or decreased first costs which indicates that P.W.F. is not considered more expensive than concrete in urban areas. The majority also believed that P.W.F. improves energy performance and comfort. A lesser number (65%) thought that P.W.F. would decrease construction time, but not labour time. They also thought that P.W.F. requires higher labour skills. About (50%) regarded P.W.F. as better looking than concrete and a significant number (30%) were concerned about safety. There was no consensus on life cycle costs or durability.

When it comes to considering the benefits P.W.F. confer on the builder (question 16) there was also a split in opinions. While the majority (80%) believed P.W.F. is difficult to try, they were not so definitive on the rest. Of those that have used it only 50% considered it to provide relative advantage while 20% said it resulted in a disadvantage. Even larger percentages (50%) thought it incompatible with standard practices, more complex to build and more difficult to explain to house buyers.

There was a definite split of opinion on whether installing a P.W.F. was not a financial burden. On the other areas of risk the builders offered very little consensus with almost the same number of builders perceiving high risk, medium risk or low risk in each category.

The interview results indicate that P.W.F. is controversial. Individual builders had highly variable opinions on P.W.F. with those disliking it expressing it in a personal way while those liking it being much more objective in their opinions. P.W.F. seems to require such a change in construction methods that it represents a conceptual hurdle to builders who think the "old ways" of building are better. This is not helped by the conflicting claims being made by the manufacturers and suppliers of the competing materials, concrete and preserved wood. Some builders actively discourage owners from wanting P.W.F. In addition builders who like P.W.F. have noted that while house buyers have an opinion on P.W.F. it appears to vary in accordance with location (urban and rural) and age of the buyer. Young buyers are more receptive than older purchasers.

4. RIGID FOAM INSULATION AND FRAMING SYSTEM (NASCOR SYSTEM)

Most of the builders interviewed have not used the Nascor System and those that have (30%) are located in the Calgary region near the product manufacturing plant. A majority (65%) however were interested in the system and would look into it in detail if a home purchaser wanted it. A lesser number (50%) would listen to the subtrades comments on the system. Most (80%) thought the present market acceptance is low although a number attribute this to the apparent newness of the system.

Because the Nascor System has been used by so few it is not possible to obtain a good reading on how builders see the system contributing to the construction process (question 15) but some trends are clear. It appears the system reduces construction and labour time, and improves energy performance and comfort, but at the same time has such high material costs that overall first costs are increased. On all other factors including labour skills, life cycle costs, safety, appearance and durability there was no indication of a trend in builder opinions.

The builders that have used the system saw it as producing mixed benefits to the builder (question 16). They saw it as producing relative advantage in marketing an energy efficient house but difficult to try and complex to build. They thought the system not really compatible with present construction practice although some could see how it could be fitted in. With repect to the ease of explaining the system, there was no consensus with just as many saying it was difficult to understand and explain as those who thought it was easy.

For those that have used the system there was a low perception of risk in all categories (question 17) except market risk (high) and to a lesser extent financial risk (medium) and management risk (medium). For those that have not used the system, it was essentially due to them not knowing much about the system and perceiving product and market risk.

The interview results indicate a less inherent distrust of the system as sometimes was expressed for other products. The system is considered new by all builders who also expressed a concern for long term market acceptability which is probably natural for all new systems. Those that have used it generally liked it and those that have not are interested in trying. The lack of information these builders have about the system is also coupled with lack of knowledge about supply, delivery and technical support. This would suggest that the manufacturer is not marketing effectively.

5. DRYWALL CLIPS

Essentially all of the builders interviewed (95%) knew little or nothing about drywall clips and only one had actually used them in the past. Although they were not using them now, after hearing a description of what they were, most builders thought that home purchasers would have little to say about their use, but were prepared to let the drywall subtrade use them if they wanted to.

The one builder that had used drywall clips thought that drywall clips contributed to the construction process (question 15) by decreasing construction, labour time and labour skills, and material costs thus decreasing first costs. He thought it made no contribution to any other factor.

The same builder thought that drywall clips' primary advantage to the user (question 16) was through reduced costs, although these were thought to be small. The clips were also easy to try and required little skill to use. The principle is also easy to understand and integrate into current practice.

When it came to risk (question 17) most builders did not see much risk in using clips even though they had not used them. Their biggest immediate problem was that they know little about drywall clips or where to get them.

The interview results indicate a complete lack of knowledge of drywall clips. Moreover few expressed any great interest in the clips although a number had "sort of heard" about them some time in the past. Apparently the whole issue of backing the edges of drywall is not a serious concern to builders, since they believe there is little absolute cost in the work anyway. Presently it is done by framers generally using left over lumber and whether they do it or not will, most builders believe, result in no change in framing costs. There would however be extra drywall costs if the drywaller installs the clips. The builder thus believes there actually be an increase in costs.

6. AIR TIGHT DRYWALL APPROACH (A.D.A.)

A.D.A. was not a familiar concept to most builders and none interviewed had actually used it. Interest was quite high, and after hearing a description of it most (80%) would consider a home purchaser recommendation particularly if the owner was looking at energy conservation. A majority (65%) would even let the drywall trade use it if the trade recommended it (and it was approved by code). Since none of the interviewed builders has used A.D.A., they assumed it has no market acceptance as yet.

Since no builder had actually used A.D.A. most felt they were in no position to discuss its contribution to the construction process. Those that did try were clearly not sure since there was consensus in any factor. There were also no results on whether A.D.A. conferred any benefits to the builder (question 16) although informally most thought that based on their immediate understanding of the concept that there would be.

In discussing risk (question 17) those that ventured an opinion (50%) though that there was not likely very much risk in any category assuming that they understood the concept correctly. All needed much more information on the concept before making any commitment.

The interview results indicate an almost complete lack of knowledge of A.D.A. Although there was high interest, this interest seem to stem from the apparent possibilities of saving money by not using polyethylene but was tempered by a concern for where the drive for air tightness was taking the building industry.

7. PREFABRICATED WOOD "I" JOISTS

Almost all of the builders interviewed (85%) have used Wood "I" Joists and believe they have high market acceptance. An even higher number (95%) would use them at home purchaser request, but less (50%) would act on a subtrade recommendation. Interestingly, although a high number have used the Wood "I" Joists, they use them sparingly and in only a few houses.

Builders generally had a clear idea of how Wood "I"'s contribute to the buiding process (question 15). Wood "I" Joists tend to decrease construction and labour time and improve appearance (clear spans) and durability. They are much more costly to buy than standard lumber and therefore tend to increase first costs. The majority (60%) of builders believed that Wood "I" Joists make no difference to labour skills, life cycle costs, energy performance, comfort or safety.

Builders also had a clear idea of the benefits prefabricated Wood I Joists confer on the builder (question 16) a large majority (80%) see a relative advantage in the large spans and pre-engineered quality of the joist. They are easy to try and compatible with present construction methods although some (40%) say they are a little more difficult to install. They are easy to understand and explain to home buyers. Virtually all (95%) believed there is no risk in using Wood "I" Joists.

The interview results indicate that builders are fully informed about Wood "I" Joists and are favourably disposed to using them if they were cheaper. At present the Wood "I" Joist costs so much more than conventional framing that builders and house buyers cannot justify the additional costs except in unusual circumstances where long spans are required.

8. THE "7-S" STRESSED SKIN PANEL SYSTEM

The "7-S" System is completely unknown to builders. Not one had heard of the system, which is not surprising given the developmental status of the system. In addition after hearing a description of the system and reviewing a brochure, there was little favourable response. Most builders (85%) would not accept a purchaser recommendation on its use nor would they consider subtrade use. This initial reaction was some what tempered by the view that should the system have some level of acceptance elsewhere they would look at it.

Regarding the contribution that the "7-S" System might make to the construction process (question 15) none was prepared to venture a guess. Similarly on the benefits the innovation might confer on the builder (question 16) there was no opinion. Only in the area of risk (question 17) was there any opinion with a small number of builders (15%) venturing that there was high product, competitive, market, and liability risk involved. All believed that a great deal of information on the system would have to be made available before anyone would use the system.

The interview results indicate that not only is the "7-S" System completely unknown, when it does become known it will likely be fighting a strong negative attitude among builders.